Engineering News-Record

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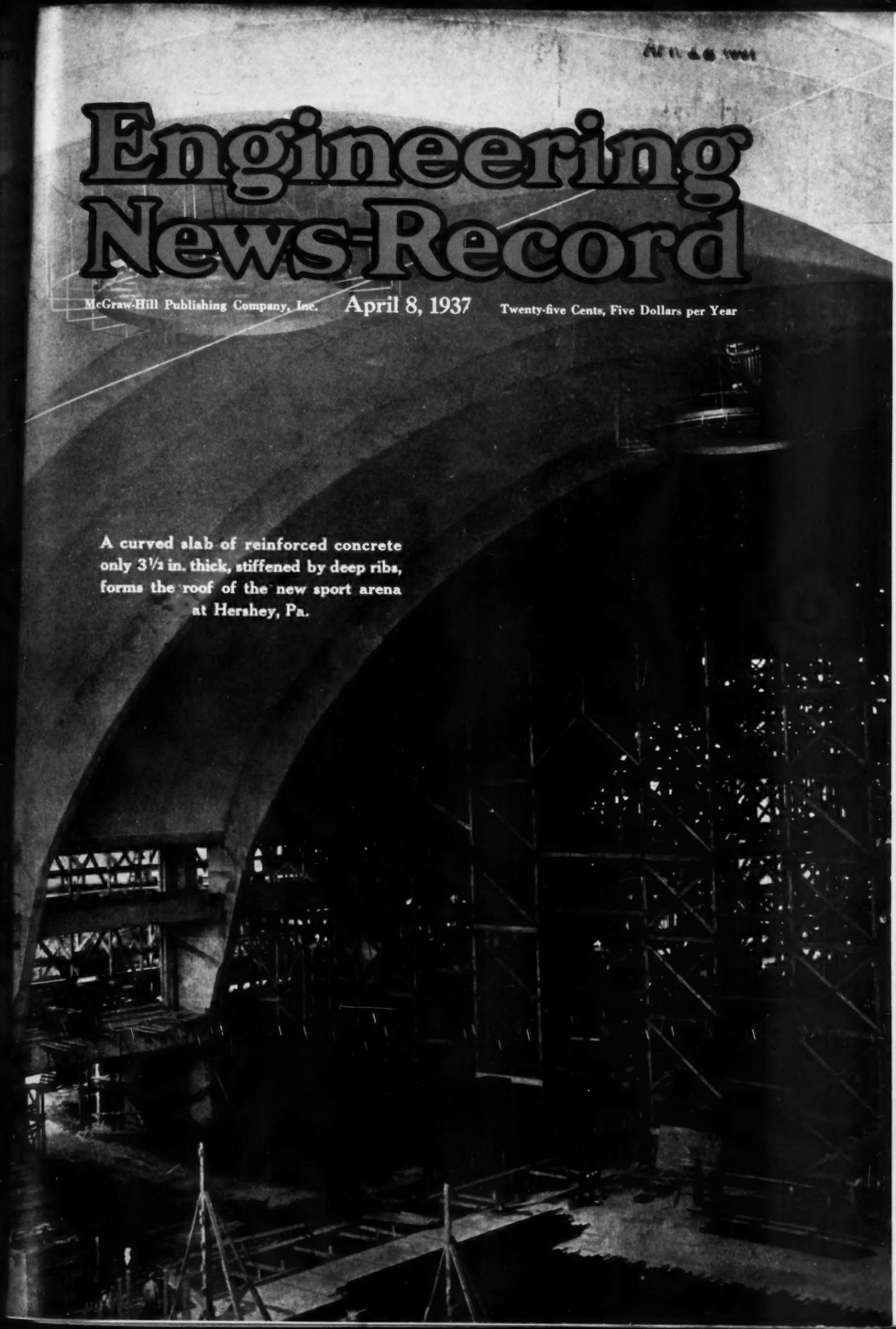
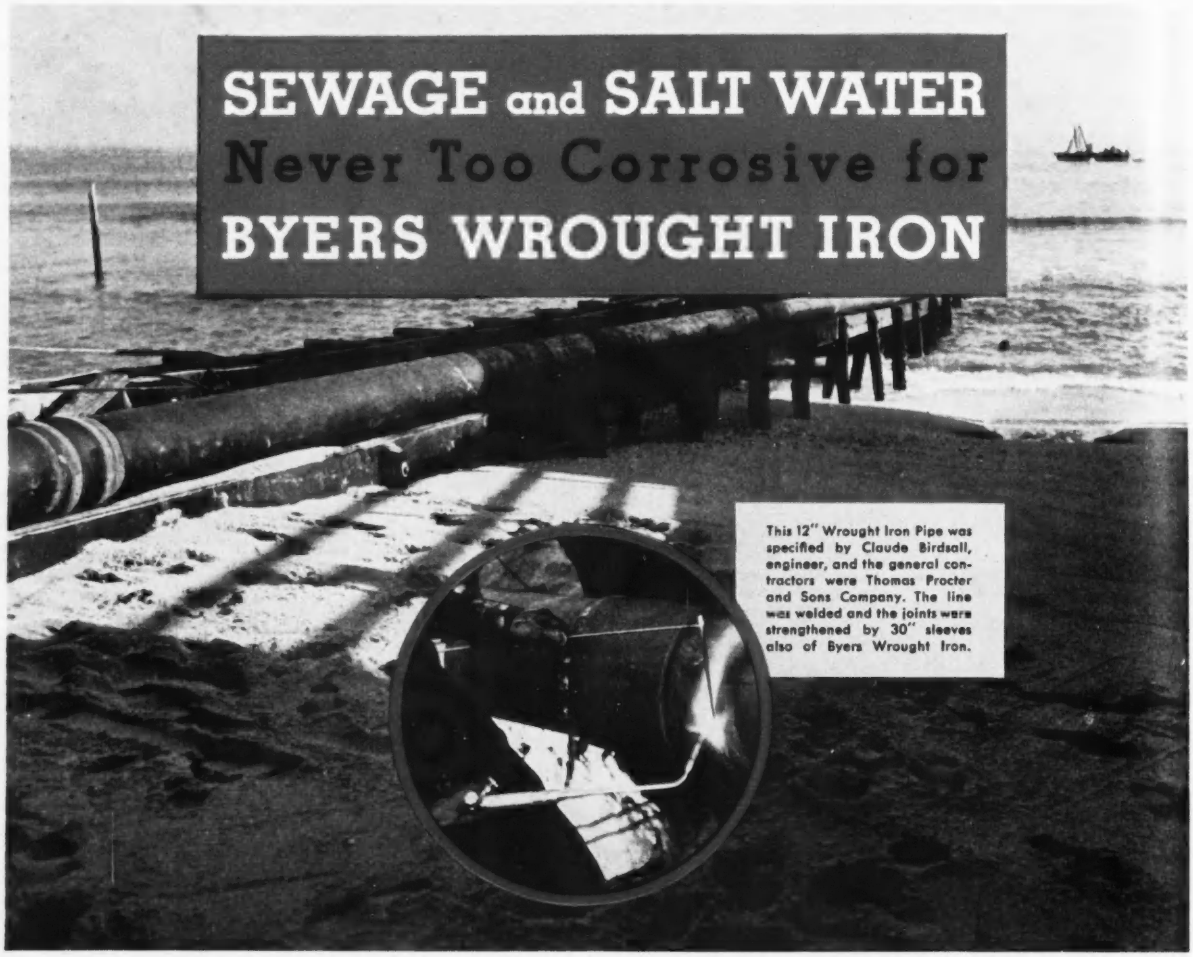


A curved slab of reinforced concrete only 3½ in. thick, stiffened by deep ribs, forms the roof of the new sport arena at Hershey, Pa.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● When engineers must select material that can stand a double dose of corrosion, usually it's wrought iron. Illustrated is a good example. The sewage engineer knows wrought iron can stand up under the sulphides, nitrates, chlorides, phosphates and carbonates—both gaseous and liquid—common to sewage disposal, and the engineer who is familiar with material that has to stand up in salt water, knows that wrought iron is an old marine standby.

Naturally, when it comes to both sewage and salt water corrosion, as in this sewage outfall line at Avon, N. J., Byers Wrought Iron gets the job. Furthermore, wrought iron, well known for its ability to withstand shock and vibration, is also the ideal material for outfall lines because settling and shifting are encountered.

Two interesting reports covering both these subjects, "The Use of Wrought Iron in Salt Water Services" and "Wrought Iron in Sewage Treatment Plants," will be sent you on request. When you write for these, tell us the work you have up, and we will be glad to assist you in determining the severity of corrosion you can expect.

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GOOD MANAGEMENT— Essential of Technical Progress

IN a recent radio broadcast, W. J. Cameron of the Ford Motor Company made very effectively a point that has been discussed now and then by this page. He was demonstrating the importance of good management to the wage earners of American industry and to the consumers of its products. And, in doing that, he described the only process by which scientific and technical progress can be made useful to the people as a whole.

In their more mystifying and spectacular aspects, the achievements of the scientists and engineers are of fascinating interest to everyone. They are of more practical concern to the industrial executive who applies them in the operation of his plant. But it takes a lot of money to keep the scientists and engineers at work. This cost of technical progress is paid, directly or indirectly, by everyone—wage-earners and consumers as well as by the employers who actually pay the bills out of their own funds.

SO it will be obvious that if we are to get back what we pay for technical progress we must put its findings to useful work. We must use them so that men will earn more for less arduous effort, so that savings will earn more when they are invested, so that consumers will have more goods or better goods for the same price. To do that is the function of management; the best management is that which contrives to accomplish all three of these objectives.

That is why it pays society as a whole when management makes available to labor the most efficient plant that technology can produce. As Mr. Cameron puts it; "We have definitely passed the point where men can earn more simply by working longer and harder;—improvement does not come that way these days; it comes solely by enhancing individual usefulness through modern tools and efficient management of work." And the provision of those modern tools is one of the signs of efficient management.

He tells us that during the last eight years the Ford Motor Company scrapped 46 per cent of its entire plant to the tune of $175,000,000 and replaced it with $217,000,000 worth of new equipment, an average expenditure during the eight years of 2¼ million dollars a month. Most of the equipment scrapped, he says, was in excellent condition, but it was no longer worthy of use because more economical plant and better methods were available. "In the Ford Motor Company," he declares, "*a thing is obsolete, no matter how good it is, the moment something better appears.*"

What is true of the Ford Motor Company is true of all progressive industry. Where it is not true, the company and its investors pay in loss of efficiency, the public pays in lower values of product or unnecessarily high prices and the wage-earner pays in less employment and lower wages. "Bad management," as Mr. Cameron points out, "is always a charge against the public; good management is always a contribution to the public."

FAILURE to grasp this fundamental truth has led to much of the mistaken emphasis during recent years on the mere making of jobs as a contribution to economic well-being. Money spent to make jobs, regardless of efficiency, will, to be sure, provide wages for those who get the jobs. But unless those jobs are *well managed* and unless the workers have efficient tools with which to work, the net result will be a loss rather than a gain to the community. Only the money spent under wise management by efficient methods contributes to the making of better things or the rendering of better service at lower cost. Only by doing that do we create higher values for consumers and higher wages for workers. Any other procedure consumes more than it returns.

What is true of the manufacture of motor-cars is equally true of the construction and maintenance of highways, waterworks, sewerage works, buildings, flood control, irrigation works and every other product of engineering construction. And all this is not merely a matter of efficiency: this is the *only* way by which the people as a whole—workers, investors and consumers—possibly can derive benefit from the amazing achievements of modern technology.

Willard Chevalier

ENGINEERING NEWS-RECORD Published every Thursday. Vol. 118, No. 14. Price 25c per copy. Subscription, domestic, Canada, Mexico, Central and South American countries, $5 per year. All other countries, $9 a year or 36 shillings. Entered as second-class matter October 29, 1936, at the Post Office at Albany, N. Y., under the act of March 3, 1879. Printed in U. S. A. Cable address "McGrawhill New York." Member A.B.P. Member A.B.C.

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Editorial and Executive Offices: 330 West 42d St., New York. Publication Office: 99-129 N. Broadway, Albany, N. Y. Branch Offices: 520 N. Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, London, W. C. 2, England; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga.

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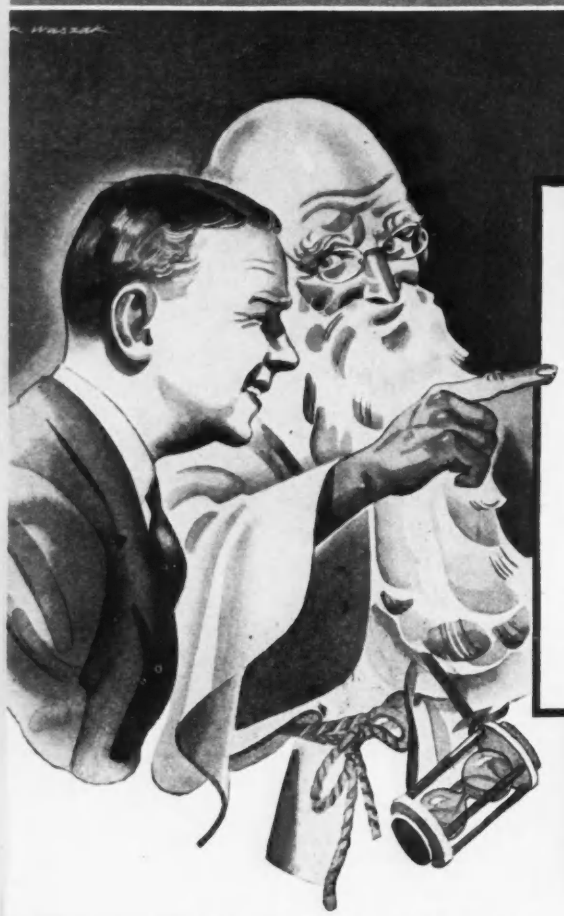
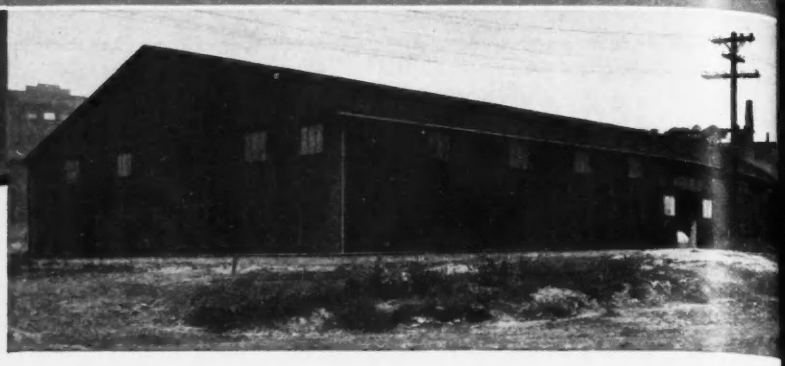
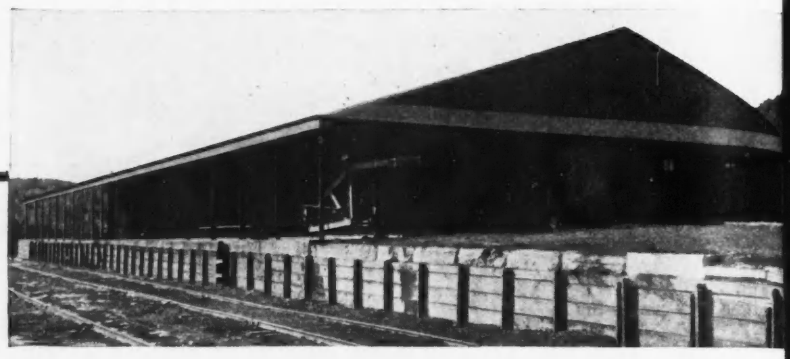
Conchas Dam **on the South Canadian River in New Mexico was put under contract last fall after preliminary work had been done with relief labor. The structure, designed to meet unusual geologic conditions, will be described in next week's issue, together with an account of the extensive hydrologic studies that were made as part of the preparatory work.**

"TIME · *The wisest counselor of all*" POINTS THE WAY





The Truscon Standard Building, illustrated above, was erected in 1922. Three years later, its owner's requirements changed. Another company wanted the building but not the land. The building was sold... dismantled ...moved to another city and re-erected with the addition of a canopy as illustrated below. Today, this Truscon Standard Building is 15 years young!



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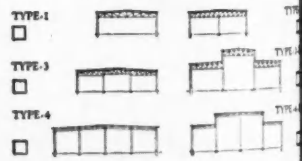

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FIG. 1—FIRST-NIGHT AUDIENCE in the ice hockey arena at Hershey, Pa., the roof of which is a concrete shell only 3½ in. thick.

Large Concrete Shell Roof Covers Ice Arena

By Anton Tedesko
Engineer of Structural Design, Roberts & Schaefer Co., Chicago, Ill.

THE most impressive example in this country of the thin concrete shell roof has recently been completed in Hershey, Pa. Of barrel type, only 3½-in. thick (except at the edges) and supported by two-hinged concrete arches, the roof covers an area 232-ft. wide by 340-ft. long within which 7,180 concrete bleacher seats surround a standard 85x200-ft. ice skating floor. Known as the Hershey Sports Arena, the new building is the home of the Hershey Hockey Club. It is built entirely of concrete to a design developed to achieve both monumental appearance and permanence at a reasonable cost.

The roof, the most distinguishing characteristic of the building, is built in five units separated by four expansion joints. In the two end units, 52½-ft. long, the roof barrel spans 32 ft. 2 in. from the end wall to the first arch and then cantilevers 19 ft. 7 in. In the three intermediate units, each 78 ft. 4 in. long, the roof barrel is supported by two arches, 39 ft. 2 in. apart, and cantilevers 19 ft. 7 in. beyond each arch. At the cantilever ends of each unit a stiffening rib is provided along the entire curve of the roof. The arches are symmetrical and two-hinged and have a theoretical span of 222 ft. and a rise of 81 ft., which places the crown 100 ft. above the ice skating floor. The two-hinged design was chosen because the arch footings are partly on clay and partly on rock. Also, the depth of the arch section is reduced at the crown, so that an approximation to three-hinge action is obtained.

The Zeiss-Dywidag roof design, or "Z.D. System" of which the Hershey Arena is an example, has been used rather extensively in Europe (*ENR*, Feb. 21, 1929, p. 321 and April 14, 1932, p. 537) where it was first developed for spherical domes and later for barrel-vault roofs. A somewhat similar line of development has occurred in this country, the Hayden Planetarium dome in New York (*ENR*, July 25, 1935, p. 105 and Jan. 2, 1936, p. 23) preceding the barrel roof of the Hershey Arena, although smaller barrel roofs were erected as, at the Chicago Century of Progress Exposition (*ENR*, June 14, 1934, p. 775 and Nov. 7, 1935, p. 635). In general, the design is based upon the fact that a thin curved concrete shell can be given load-carrying capacity by providing it with stiffening ribs. Such a shell, in its major portion, is subjected to direct tensile, compressive and shear stresses and not to transverse bending moments. A thin reinforced section is strong enough to take care of these stresses; the roof loads are transferred to the stiffening arches by tangential shear.

The arches of the Hershey building, 22 in. wide by 60 in. deep at the crown, increase in depth toward the springing line of the roof and are thick enough at the level of the gallery to permit piercing with 5x7-ft. openings. The arches were computed as statically

"TIME · *The wisest counselor of all*" POINTS THE WAY

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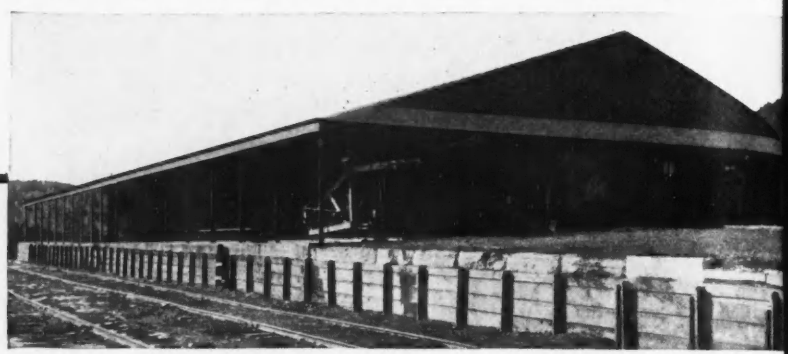

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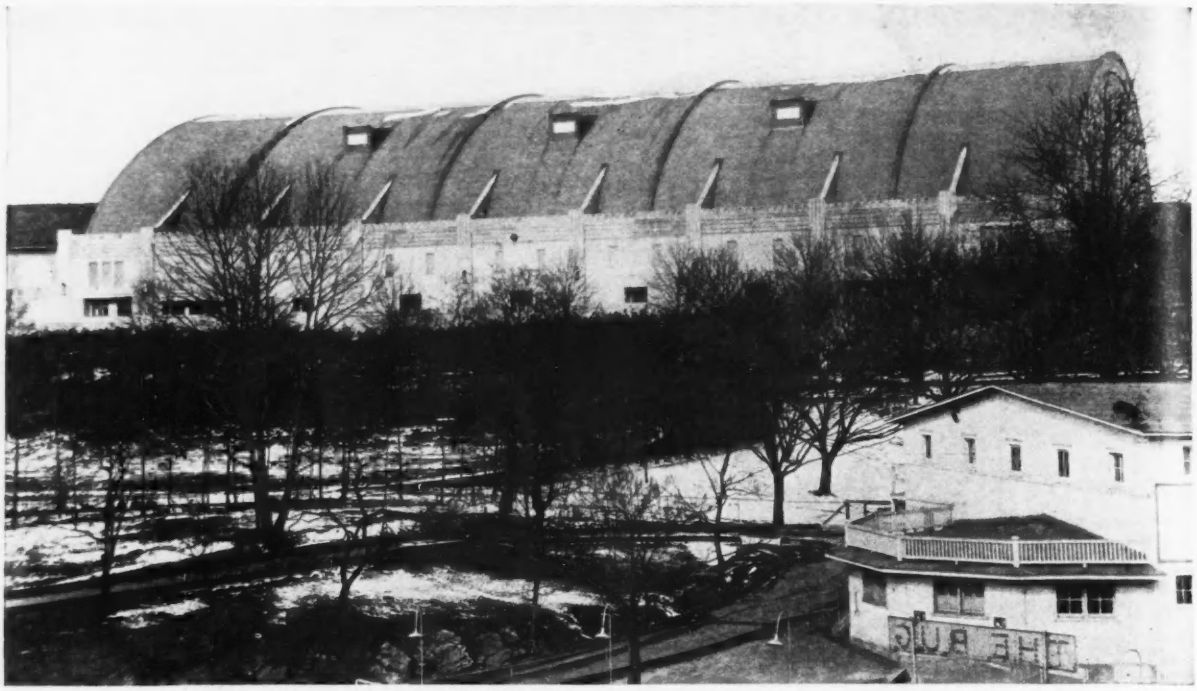


FIG. 2—THE HERSHEY SPORTS ARENA has over-all dimensions of 245 x 356 ft. This view of the exterior shows the four copper-flashed expansion joints that divide the concrete roof into five units, the ventilator houses carried by the concrete shell and the protuding haunches of the supporting arches.

indeterminate structures. Moments, shears and axial forces in the arches were calculated separately for the arch and shell dead load, the load of roofing and insulation, live load, loads on side slabs and galleries (symmetrical and non-symmetrical), wind loads, temperature, shrinkage, and movements and deformations (as from rib shortening). The snow load was assumed at 25 lb. per sq.ft. of horizontal projection near the center of the span, but where the wind might blow snow into each of the flat side roofs, the snow load was increased to 150 lb. The wind was figured and distributed as outlined in an April, 1931, research paper of the U. S. Bureau of Standards, using a true wind speed of 115 m.p.h. or 35-lb. per sq.ft. velocity pressure, windward surfaces receiving positive pressure and leeward surfaces receiving suction. It was assumed that the structure would be built at an average temperature of 60 deg. F., and warming up of 40 deg., and cooling off of 90 deg. were taken into account. The value for shrinkage was considered equal to an additional cooling of 25 deg. F. The influence of a 1-in. vertical or horizontal movement of the arch footing was also taken into consideration, whereas the actual movements proved to be $\frac{1}{4}$ in. horizontally and $\frac{3}{4}$ in. vertically.

In Fig. 4 is shown the typical reinforcing of an arch near the crown and near the point of maximum negative moment. Plain 1¼-in. diameter reinforcing rods are used, spliced by means of threaded-sleeve turnbuckles; to achieve an unyielding connection, the threaded sleeves were set under an initial stress. Tests indicated that the sleeves develop the full strength of the spliced threaded bar.

Special hinges used

The arches were designed for a maximum reaction of 1,100,000 lb., and the maximum rotation at the hinge point under extreme loading conditions is 24 minutes. Since bridge-type pin bearings were too costly, soft lead plates in combination with Mesnager hinges were used. Bars 1 in. in diameter, which are small enough to take the bending stresses due to rotations without being overstrained, were chosen for the hinges, (Fig. 6).

The lead plates were the subject of some special tests by the engineers which showed that there is a more or less definite yield point for lead so long as it is uninterruptedly kept under a pressure that is not materially released. Under the relatively high constant pressure of the dead load of the roof, with only slight changes caused by live load, it could be assumed that the lead would exhibit an elastic behavior below an established yield point. Since it was not possible to continue the tests over a long period of time to study plastic deformations, the lead plates were confined in metal frames of galvanized angle irons, to eliminate any tendency to flow.

In the hinges, the lead takes most of the normal pressure while the fanlike reinforcing bars take the stress due to rotation as well as prevent any motion due to differential thrusts in the direction of the plane of the lead. All joints around the bars and the lead were filled with asphalt and cork for protection against corrosion and to make sure that forces are not transferred between the arch and the abutment except at the center of the hinge. The top of the foundation and the lowest portion of the arch are well reinforced horizontally to resist tensile stresses due to lateral deformation, so that these concrete parts are able to take high vertical unit pressures in the neighborhood of the hinge.

The cylindrical roof shell

The reinforced concrete shell was poured monolithically with the arches and thus is restrained at the arches as well as by longitudinal edge members bordering the horizontal side slabs. Throughout its major portion the shell has a radius of curvature of 132 ft., but near the springing line this radius is reduced to 42 ft. to increase the stiffness near the horizontal boundary of the roof. Such strengthening of the free edges of a curved shell is common practice in the metal-working industry for such products as automobile fenders, dishpans, etc.

The roof was shaped in accordance with the latest experiences on plastic flow. It has been found important for shells to employ cross sectional curves that deviate considerably from a parabola, which under an evenly distributed load would not have any carrying capacity between stiffening arches, and would

exert a thrust at its springing line that would have to be resisted by continuous abutments or girders. A circular or elliptical shell, on the other hand, would have considerable longitudinal carrying capacity between stiffening arches, while a shell shaped according to a cycloid would be the ideal shape although impractical from a construction standpoint. The shape of the Hershey roof closely approximates an ellipse. The shell thickness is 3½ in. over most of the roof; near the springing line it is increased to 6 in., and a 5-in. thickness is used near the crown where heavy concentrated loads have to be carried.

The curved shell between the arches serves a number of purposes in addition to acting as the protecting roof. Structurally it is similar to a girder of 39 ft. span, and may be compared to the upper part of a pipe of 132 ft. radius. Having great rigidity and a high section modulus, it serves as lateral bracing for the arches and also acts as the compression flange of a T-beam in which the arch is the stem; the theoretical width of this flange is 8 ft. 11 in. The shell also relieves the arch of stresses in the crown due to vertical loads.

To understand the last mentioned action, comparison may be made with a pipe filled with water. In such a pipe the water produces tensile ring stresses that are proportional to the pipe radius and to the water load. In the shell roof, outside pressure due to dead and live loads is substituted for the inside water pressure of the pipe; the resulting ring stresses are comparable to those in the pipe except that they are compressive instead of tensile. Referring to Fig. 5: to preserve equilibrium, the total of the horizontal forces in the crown cross-section of one complete intermediate roof unit must be equal to the horizontal thrust of the roof unit. The compressive ring stresses, T_2, must therefore be balanced by a horizontal tensile force, T, existing in the upper fibers of the arch and of such size that the algebraic sum of the compressive ring stresses and tensile arch force equals the arch thrust. (For a number of loading conditions this tensile force T happens to be even larger than the arch thrust.) Although vertical loads near the center of a two-hinged arch produce downward bending in the center of its span, the tensile forces from the shell action occurring in the crown of the arch at its upper edge produce an upward bending, relieving the arch of dead load stresses. The shell slab, therefore, is an aid to economical arch design, permitting a smaller arch section. Near the points where, on account of negative moments in the arch, the shell with its upward bending action would increase these moments, the shell is placed below the extrados of the arch; instead of producing tension near the upper fiber of the arch, the shell then produces tension near the neutral axis of the arch.

It may be worth mentioning that nothing exists of what is usually termed a "thrust" at the springing line where the shell connects to the horizontal stiffening slab. On the contrary, there is a slight tension in the direction of the cross sectional curve of the shell, which means that the shallow edge girder hangs on the shell. Due to its dimensions the shell is very stiff in the direction of its tangential plane and can hardly deflect in this direction; the horizontal side slab also helps to prevent buckling. Limitations for the dimensions of a shell are set by the danger of buckling, which grows as radius and span increase and as thickness of the shell and edge restraint decrease. The design against buckling was made in accordance with the methods published by W. Flügge in his book "Statics and Dynamics of Shells" (Springer, Berlin, 1934).

The shell stresses were figured according to the membrane theory and by U. Finsterwalder's method which was explained and enlarged upon by H. Schorer in *Transactions*, Am.Soc.C.E., Vol. 59, No. 98, p. 101 (1933) Design of Large Pipe Lines, and Vol. 62, No. 101, p. 767 (1936) Line Load Action on Thin Cylindrical Shells.

A so-called "membrane stress system" in which the direct stresses are in equilibrium with the surface loads, exists in the major part of the shell. To understand this membrane stress system, it is helpful to note that one-half of an egg shell is not as strong as an unbroken egg because a direct stress system cannot develop in all directions, being disturbed by zones of structural weakness at the free edges. With the shell stiffened at the free edges, as it is in the roof, the edge loads are transmitted to the more central portions of the shell by a plate action. The stresses, radiating from the edges belong to a second system, a so-called "rim stress system," occurring wherever the shell connects to the arch and in the region of the horizontal edges of the shell. It is important to evaluate these "restraining" stresses correctly since they often are many times larger than the membrane stresses to which they are added. On the other hand, they decrease

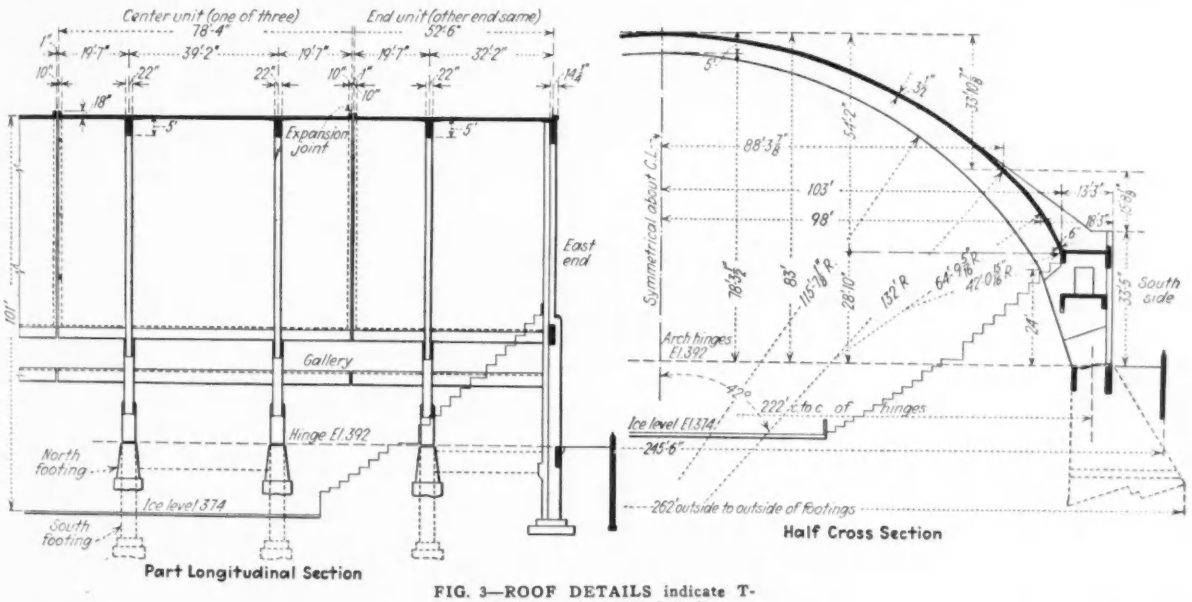


FIG. 3—ROOF DETAILS indicate T-beam character of arch and shell combination and the stiffening of the shell at its edges by reducing its radius of curvature and thickening the section.

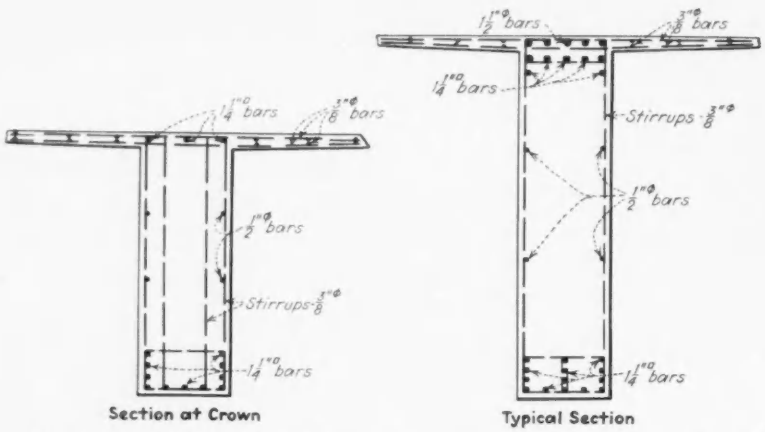


FIG. 4—REINFORCING DETAILS of concrete shell and arches in the Hershey Sports Arena roof.

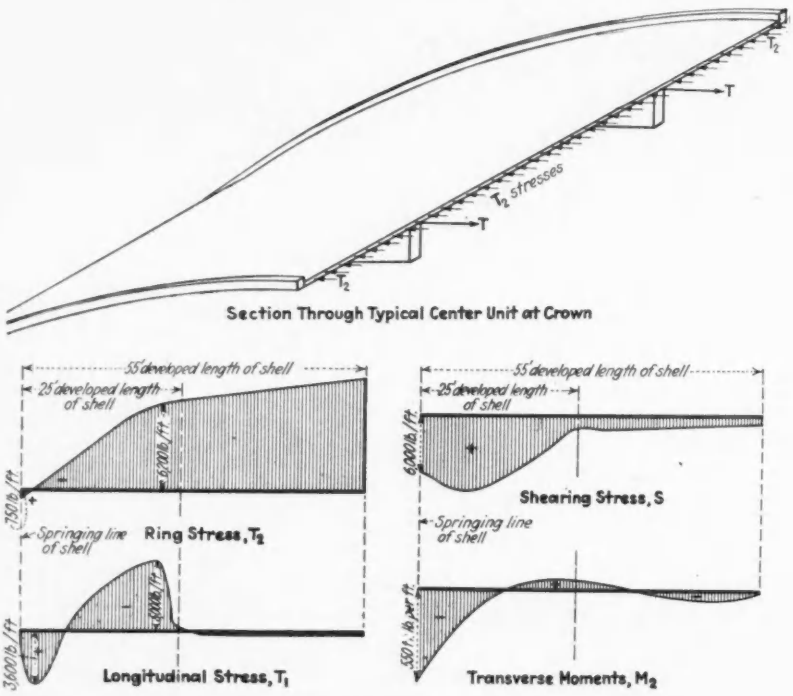


FIG. 5—STRESSES in concrete shell roof. Section at top shows stresses at the crown and four other sketches indicate stress distributon. Shears are taken adjacent to an arch; stresses and moments midway between two arches.

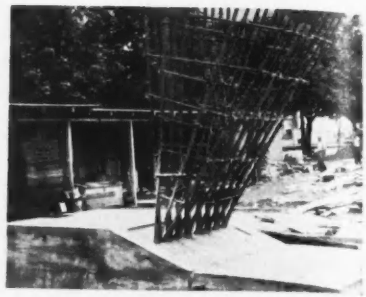


FIG. 6—REINFORCING BARS forming the semi-hinge between the arches and the footings.

rapidly a short distance from the edges and may be taken care of by a slight increase in the thickness of the shell and by adequate reinforcing. In the Hershey roof, for example, the shell thickness at the springing line is made 6 in. but reduces to 4½ in. in a distance of 3 ft.

The distribution of the rim stresses along the curve of the shell is similar to that of the ordinates of a dampened wave. The rim stresses combined with the membrane stresses in the shell under dead load and full live load are shown in Fig. 5. The stresses T_1, T_2 and M_2 are given for mid-span between arches while the shear stresses are given at the arch. For reasons of clearness, these stresses are shown as if the shell were to carry only between the two arches, without any overhangs.

Where the shell is under membrane stress condition only, its reinforcing is very simple and in two directions. Where the edge load conditions govern the stress distribution, the resulting principal stresses for the most unfavorable loading at each point of the shell were calculated and their proper angle with the horizontal determined. Sufficient steel bars were placed in the direction of the stress trajectories to take up safely the principal tensile stress; the concrete takes care of the principal compressive stress. The resulting curves in which the steel had to be placed are shown in Fig. 8.

In addition to the thickening of the shell near the springing line, it was also necessary to increase the thickness to 5 in. near the crown of the center sections to carry concentrated loads of 14,000 lb. from loud speaker supports and lighting fixtures. Six fan houses with ventilating equipment and motors are likewise supported by the shell alone, and necessitated local strengthening of the shell and additional reinforcing.

The action in the two end units of the building is similar to the action of the center units, except that a stiff end wall is substituted for one deflecting arch. The equivalent for the tensile force in the top of the arch, as previously described, is therefore a tensile force taken by a curved tension member on top of the end wall. Wind load on the end of the building is taken by the columns in the end walls and by the arch 32 ft. 2 in. distant. The columns were designed to resist moments due to suction as well as positive wind pressure, while the semi-hinges of the arch are able to take moments which are not in the plane of the arch itself. All but one of the columns of the end walls are partly restrained in the bleacher structure and in the floors, and this affected the moment distribution. The column that is not framed into the seating structure is on the axis of the building where an expansion joint is provided in the bleachers; this column was strengthened by an independent A-frame.

Construction procedure

For constructing the Hershey building, a hoisting tower and two mixers were placed near the center of either side wall, and a system of runways connecting with the towers at different elevations made it easy to run concrete buggies to all points where concrete was to be poured. The footings and hinges were placed first, after which the haunches of the arches were built

up to a point about 30 ft. above the hinges. The gallery beams, connecting and stiffening the arches, were poured integrally with the haunches. Then, in one continuous operation, each roof unit was constructed.

The centering for the roof was built of individual scaffolding towers braced horizontally at two levels. Screw jacks located on top of the towers carried timber trusses shaped to the curve of the roof, while joists between the trusses supported the 4x8-ft. wood form panels. An unduly large amount of lumber was used in the centering (200,000 ft. b.m.) since the builder had only short lengths in stock and thus many splices were required.

With the scaffolding in position, the curvature of the roof was checked with templates, the form panels covered with acoustical cork slabs, and the concrete poured. The cork adhered to the concrete without special anchorage, and when painted provided the finished inside surface of the roof.

Concrete placing was done symmetrically from both sides of the arch, and a continuous roof pour occurred once a month. The actual pouring of the first intermediate roof unit required 54 hr., but only 26 hr. were required for the third unit because of the greater experience of the workmen.

The concrete was cured for a week, and the centering remained in place from ten to seventeen days after completion of the pour. Before striking the centering deflection tests were made on beam specimens of the shell concrete to check its elastic properties, since a minimum modulus of elasticity of 3,000,000 lb. per sq.in. after 28 days had been specified.

Decentering was accomplished by the gradual lowering of the 200 jacks, which dropped the trusses on top of the scaffolding towers. The decentering operation was controlled by telephone from a point on the ground, using a series of vertical wires hanging from the roof to give a progressive picture of the arch deflection. The actual deflections of the arches when decentered were within 5 per cent of the calculated $1\frac{1}{4}$ in., which is 1/2,000 of the span. After decentering, the scaffolding was moved on steel rod rollers to a position under the next roof unit. Four 10-ton chain blocks were used to move the scaffolding in two 140-ton sections.

The roof slab received a float finish. Wooden blocks were placed in the slab when it was poured to serve as nailers for 1-in. fiber boards on which the built-up roofing was placed. The expansion joints between the units were covered by a sliding copper flashing.

Concrete mix

The arch frames, the end wall columns, connecting members and the roof shell were designed for a 3,000-lb. concrete which, on the basis of 28-day tests, showed an actual strength in excess of 4,000 lb. per sq.in. The mix averaged 1:2.75:2.25 (cement, river sand and crushed stone) with about 5 gal. of water per sack of cement. The amount of water added at the mixer changed with job conditions. In addition to the differing water content of the sand and stone used, evaporation on hot summer days caused considerable water variation. Evaporation was particularly noticeable during the pouring of the $3\frac{1}{2}$-in. shell, and much better results were obtained when the roof was poured at night. Somewhat less water was used in the concrete for the lower part of the roof shell than elsewhere, to prevent its sliding on the steep surfaces. Taking the job as a whole, the water-cement ratio varied between 0.65 and 0.80.

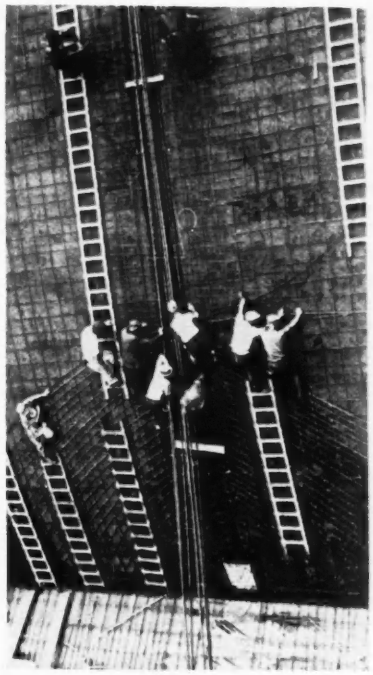
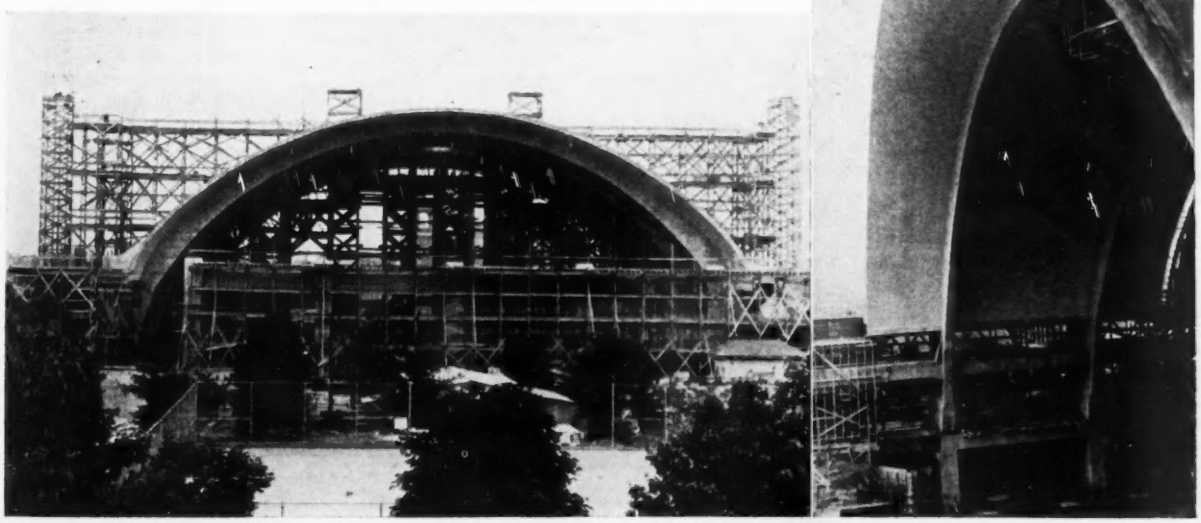


FIG. 8—PLACING REINFORCING in roof shell in lines of stress trajectories.

During the construction, jacks were also inserted in the hinge joints to support the arch haunches and to lock the hinge so that it could not receive undesirable stresses. These jacks were removed during the decentering operations, bringing the hinges into action and assuring the correct location of the thrust line. The maximum measured

FIG. 7—ROOF CONSTRUCTION was carried out on movable timber centering. Concrete hoisting towers with connecting runways were placed on either side. The roof was built in sections, one of which is shown at the right just after the centering had been removed.



rotation between arches and piers at the hinges was 35 min. during decentering while the final rotation after decentering amounted to about one-half of this value.

Seating structure

The bleachers as well as the concrete columns of the building, the footings, slab floors and wall panels are of conventional design. Seats are so arranged that all spectators have an unobstructed view of the arena floor. Expansion joints divide the bleachers and their supporting structures into four parts and also separate them from the outside walls and the roof.

Some 10 miles of pipes were embedded in the heavily insulated concrete floor which serves as the base for the skating surface and is surrounded by a tunnel containing the supply and return lines. Each of the three light fixtures suspended from the roof contains 47 searchlights and also supports loud speakers. Floodlights are arranged in the end walls, and light is reflected from the bluish white surface of the painted cork with which the end walls and curved roof surface are lined.

Windows are provided in the east wall only. Forty-six exits assure quick emptying of the arena hall. Six 5 ft. diameter exhaust fans are arranged in the roof and four in the end walls. Offices, lobbies, lunch rooms, storage space, and garage are provided on the street level and in the basement.

The structure was designed and the construction of it planned and supervised by Roberts & Schaefer Co., engineers and contractors, Chicago. The writer was in direct charge of the work. Dyckerhoff & Widmann, the originators of the Zeiss-Dywidag system, contributed their recent experiences with regard to the shaping of the shell slabs. The construction was done by Hershey Lumber Products, (D. Paul Witmer, manager and designer and Maurice C. Glace, superintendent), the construction organization of the Hershey chocolate interests, the owners, using local labor.

Wings of Bridge Abutments Serve as Counterforts

By A. E. Wall
Portsmouth, Ohio

IN DESIGNING abutments for a truss bridge over Brush Creek at McDermott in Scioto County, Ohio, a special counterfort layout was developed that shows a saving in materials over the usual cantilever design. The wings of the abutments are considered as counterforts and a single counterfort is placed in the center of the breast wall to reduce its thickness and also the size of the beam at the rear of the footing. Since the bearing capacity of the soil at the site was unsuitable for heavy loads and to reduce the amount of piling required, it was decided to construct the abutments on wide foundations. Relatively large amounts of sand and gravel had therefore to be used and since these materials had to be trucked a distance of five miles, it was desirable to limit the quantities as much as possible. Hence, the advantage of the adopted design.

The abutments were figured as single units. The entire weight of the wall, wings and footings, the backfill over the footings and the weight of one half of the bridge was used for calculating the vertical forces and center of gravity. The entire backfill between the ends of the wings was considered in calculating the horizontal pressure.

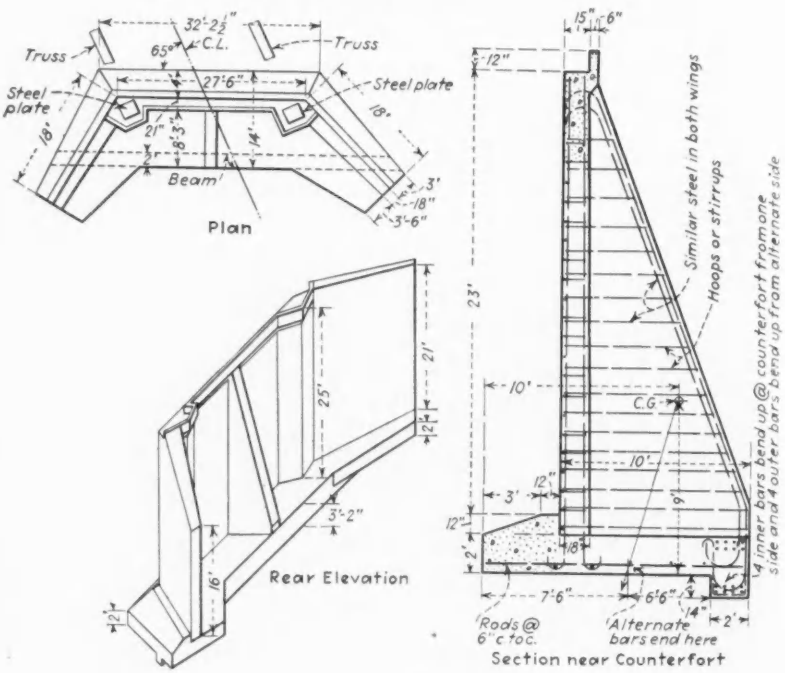
A section of the abutment near the center was drawn and a theoretical 2-ft. length was added to the rear of the footing to allow for that part of the footing extending back of the beam around the wing ends. The center of gravity of the vertical loads fell 10 ft. back from the front edge of the footing and the resultant force cut the footing 7.5 ft. back. The upward pressure at the front of the footing was calculated as 1,120,000 lb. This load is distributed over a length of 32 ft., amounting to 3,500 lb. per square foot. The upward pressure at the rear edge of the beam was calculated as 817,000 lb., which is distributed over a footing length at this point of 51 feet, amounting to 1,600 lb. per square foot. Calculations at intermediate points resulted in a curved load diagram.

The footing in the front of the wall was designed as a cantilever to resist the upward pressure, the footing in the rear of the wall being considered as a slab supporting the entire vertical load between the wall and beam, the beam as carrying one-half of this load to the counterforts. The center counterfort was considered as a cantilever beam carrying twice the load of each wing. The wings were reinforced vertically to resist the pressure of the backfill, and the wall between the wings was reinforced horizontally from wings to counterfort.

A double row of piling was placed under the front part of the footing which supports the abutment to a point where the pressure on the soil is reduced to less than one ton per square foot.

The plans were drawn by the writer under the supervision of Arthur H. Peake, county engineer of Scioto County.

BRIDGE ABUTMENT in which wing walls serve as counterforts.



When Extras Are Allowable And How to Get Them

Court decisions on allowances for alterations and extra work on government contracts reviewed and procedure for collection outlined

By George A. King
King & King, Attorneys, Washington, D. C.

FEW QUESTIONS *in engineering construction have led to more frequent dispute than claims and allowances for extra work. In many actions at law to which these disputes have come the courts have handed down decisions of utmost importance to contractors. A citation of illustrative decisions by an attorney is made for* Engineering News-Record *in the following article. Out of them the author has drawn an invaluable code of rules which every contractor should keep on file.* —EDITOR

CONSTRUCTION WORK is seldom carried out exactly as designed and specified; alterations and extras are almost certain to be required in the progress of the work. The procedure to be considered in handling such changes in mutual justice is the subject of this article. To provide a basis of common understanding the usual contract clauses bearing on the subject are given (p. 513) so that reference can be made to them as the discussion proceeds. These are government-contract provisions. In some forms of contract a board is provided to fix the cost of changes and when the contract provides for determination by a board its decision is ordinarily controlling.

When contract provisions as given are strictly observed: Orders for changes given by the authorized officer, price fixed by the officer or by the board, orders accepted by the contractor and the amount paid, no question arises.

In lauguage of much generality it has sometimes been held that where items of change are not approved by the authorized officer or not ordered in writing by the contracting officer, and no such order was demanded or given there can be no recovery for the alleged extra work. This rule is, however, subject to so many exceptions and qualifications that it can hardly be regarded as establishing a general principle.

When a change order is given in sufficient time to enable the changed work to be done within the time provided by the original contract, there is no right to an extension of time. Where the order is not given until after the contract time has expired, or so close thereto that it is impossible to do the work within the original limit of the contract, the contractor is entitled to sufficient time within which to do the changed work.

Who is authorized?

The question often arises: Who is authorized to give an order for changes which will be binding on the owner of the work?

When the head of the responsible department or bureau personally gives directions for the alterations this is an order from the authorized officer, and, if extra and outside the work required by the contract, the owner of the work must pay for it accordingly. Where the officer locally in charge acts without any authority from the head of the proper department or bureau and gives an order for a better quality of stone for the building, the government is not required to pay for it, although a better building resulted.

Sometimes the local officer in charge has imperfect authority to give an order for extras, but after he has given such an order and it is approved by the authorized head of the department or bureau concerned, this is a ratification of the action of the local officer and is equivalent to authority given in advance, and the contractor is entitled to be paid for the work as extra.

Sometimes the circumstances are such that the officer locally in charge of the work is inherently clothed with such authority that his order for extras is valid, and extras so ordered must be paid for.

Decisions on authority

The government undertook to repair and recondition the ancient vessel *Constitution.* A contract was made for this purpose based upon detailed specifications. A large amount of extra work was performed beyond the specifications, by order and direction of the naval constructor detailed by the department to superintend the work. He was the responsible and authorized agent of the United States and as such had authority to order the extra work and its additional cost in full was allowed the contractor as extra and additional to his contract price.

In one case where changes in the plans for the work were made by the government and the contracting officer refused to issue an order for the changes, his action was regarded as so capricious and erroneous as to imply bad faith and the contractor was held entitled to be paid as for extras.

Where one make of elevator was specified in the contract but it was stated that any other good make would be accepted, the contractor was held entitled to tender any suitable make of elevator, and if required to install one of particular manufacture at a greater cost, he was entitled to recover for it as an extra.

Where a contract was made for pumps for use in vessels in course of construction, and the pumps passed all the tests required by the contract, but by provision of a departmental regulation not known to the contractor nor embodied in the contract, such pumps were not to be accepted unless capable of operation without internal lubrication, the contractor was required to supply the supposed deficiency in order to make them operate in accordance with the regulation. This was extra work and the contractor was entitled to be paid for it as an extra required by authorized officers of the government and not covered by any provisions of the contract.

When a change in the method of construction of a contract involving excavation is ordered by the officer locally in charge, and seems at the time it is ordered not to involve additional cost, but in consequence of unforseen circumstances the contractor is thereby involved in heavy additional expense, he is entitled to be paid for this additional expense as an extra.

Where the agent having power to superintend the construction of a building ordered extra and better materials making the building more valuable, permanent and useful by the extra work and materials bestowed upon it

than it would have been had it been completed acording to the terms and specifications of the contract, the government was held bound to pay the fair and reasonable value of the extra work and materials furnished.

Where the officer in charge of the work and the contractors differ as to whether certain work required is extra work or not, and it becomes necessary for the contractors either to abandon their work or proceed and furnish the materials and do the work required by the officer in charge, and the contractors go on and do the work so required, they are entitled where the claim is clearly meritorious to recover the value. Such was the holding of an intermediate federal court in a well considered case.

Where items of work over and above the provisions of the contract are performed by the contractor at the request and requirement of the officer in charge of the immediate direction of the work, and some of them with the sanction of the officer having superior power, under circumstances indicating the good faith of the subordinates, the additions were necessary as it was thought by those agents, and the government having received the value and benefit of them, such items were allowable as extra and additional work.

Where a contractor was required by the officer in charge to do plastering not specified in his contract as well as to use a higher grade of mortar in laying bricks in certain stables than was required by his contract, these were held to be allowable items of extras, and this although at the time of settlement under the contract no protest was made on account of the non-allowance of these items.

Such decisions show the exceptional circumstances that may arise and appeal to the sense of justice of the courts causing them to disregard technicalities standing in the way of substantial justice.

Decisions on tests

Ordinarily work furnished by a contractor must pass a test by certain officers appointed by the contract to make the test, and unless it can pass such a test it is not acceptable under the contract.

Where a contract was made for the construction of a drydock and among other things for engines satisfactory for the purpose of pumping out the dock, the contractor furnished such engines and they were found sufficient to pump out the dock. Meanwhile, however, the officers of the owner changed the requirements so as to demand engines sufficient, not only to pump out the drydock, but to operate the entire power plant of the navy yard. On the engines failing to pass this test, they were rejected, and the contractor was required to furnish new and more powerful engines. These were held to be extra and additional to anything required by the contract and the contractor entitled to be paid for them as extra.

Where a contract required the contractor to furnish vitrified fire-clay tiles and was required in addition, not merely to furnish vitrified fire-clay tiles but glazed vitrified fire-clay tiles, the additional requirement was material and the contractor entitled to the extra cost of furnishing glazed virified fire-clay tiles. This decision illustrates the distinction made by the courts in regard to furnishing orders for changes. There no change order was demanded by or issued to the contractor as required by the terms of the contract. The contracting officer and his superior officer ruling that the contract provided for glazed vitrified fire-clay tiles, the contractor was ordered to furnish and erect the glazed tiles under the terms of the contract. A futile act is not required of the contractor. He consistently preserved his rights. The requirement of the officers that glazed tiles be furnished was outside the terms of the contract. The contractor was entitled to recover the additional cost of furnishing and erecting the glazed tiles instead of the unglazed tiles.

Decisions on risk

Sometimes the extra work ordered throws an increased risk upon the contractor. Where a breakwater was constructed of separate cribs, each crib to be completed as a separate structure, then sunk into place, packed solidly with stone, the contract providing the exact form of the bolts, as square iron bolts of a certain length, the engineer officer supervising the work for the owner substituted for the bolts provided for by the contract a round bolt of less holding power and more liable to give rise to break. The cribs parted in consequence of the action of the sea by which some of the retaining bolts were torn out and some were broken. It was held that the contractor was entitled to use the form of bolt specified in the contract, and that if there was any reason to suppose that the break in the cribs was in consequence of the change in the form of the bolts used, he was entitled to recover the extra expense of replacing the work which broke. He was not even required to show positively that the break was the result of the change in the form of bolt, but if it was even probable that the change in the form of the bolts used caused the break, he was entitled to the increased cost of the extra work which was probably attributable to the change in the form of the bolts.

Decisions on incidence

Where a contract was made for a public building and the specifications furnished the contractor failed to comply with the code requirements of the city in which the work was to be done, the contractor was found entitled to compensation for extra work done by

RULES FOR CLAIMING EXTRAS

1. All orders for what the contractor believes to be alterations, changes, extra work or any sort of departure from the terms of the contract should be obtained in writing. If the officer giving the order will not put it in writing the contractor should acknowledge the order in writing to the officer.

2. On receipt of any order for what the contractor considers alterations or extra work, involving extra expense, the contractor should at once notify the officer issuing the order that he considers it extra work and will expect payment accordingly.

3. The contractor may with safety obey the written order of the highest officer who signed or approved the contract for any alterations or extra work within the general subject-matter of the contract, taking care to let it be known in writing that he regards it as extra and outside the obligations assumed in his contract.

4. If such an order comes from an officer lower than the highest officer who approved the original contract, the contractor is responsible for seeing that the highest officer knows of the order, and knows the contractor's position in regard to it. He should notify such officer himself unless he has positive knowledge that such notice has been given by the officer in charge.

5. The contractor can not with assurance of safety obey an order of the engineer or officer in charge not approved by such superior for any alterations or extra work unless the contract was made by the officer in charge without the approval of a superior officer.

6. While it is important to follow the suggested precautions, it by no means follows that redress cannot be obtained in the courts for oppressive exactions where the letter of such requirements is not strictly followed. The great variety of possible conditions makes it impossible to state further than in the general manner above outlined, the exact cases in which relief will be granted.

7. Contractors and builders cannot always in their daily communications with the supervising engineer or inspector, whom they have strong reasons to conciliate, insist too strongly at the time on the matters in question as upon mature consideration during the progress of litigation it may appear that they should have done. The contractor's exact course of action may be tempered by a recognition of this fact, but with care and tact the essential steps above outlined can usually be followed in substance without giving serious offense.

him to avoid violation of the municipal ordinances.

In contracts for large and important work consisting of many items, such as drydocks, work is constantly being required as incident to the main purposes of the contract. In such cases the allowance of additional items such as are necessary to the completion of the contract but not provided for in the specifications has been sustained as within the authority of the engineer in charge.

Thus the Supreme Court has sustained allowances for extras for gear casing to protect the workmen from injury from high speed gearing, for night work ordered at a higher price by proper authority, for additional electrical wiring, for repairing breakage in drain pipes, and replacing a valve broken without fault of the contractor.

In a similar case the Court of Claims allowed extra pumping made necessary by defaults of other contractors who were to supply machinery for a pump house, for richer mortar than was required by the specifications and for repairing faulty method of connection between the drydock and the pump well, all of which were ordered by authorized officers.

Decisions on error

Where the cost of unloading and distributing steel was increased by lack of space requiring repeated removal of the steel and an additional crib was required on account of the work beginning at the wrong end by order of the supervising officer, these and other expenses caused by failure to adopt proper methods are chargeable as extras.

Where under a construction contract the officers acting within the scope of their authority, make an honest but serious mistake in the discharge of their duties mislocating the line of excavation and imposing upon the contractor a vast amount of additional work, which should not have been required under the contract, the contractor is entitled to recover the amount as an extra when the facts are established and the manner in which a claim for damages is to be asserted is complied with.

Much more aggrevated is a case where the mistake is not made honestly and in good faith but recklessly.

Decisions on excavation

The question of extra work often arises in connection with contracts for excavation. Sometimes only the materials to be excavated are specified in the contract, but sometimes also the methods to be employed by the contractor are specified. Description both of the materials to be excavated and the method to be employed are often of much importance in determining the the scope and meaning of a contract.

In a contract with a municipality for the construction of a sewer involving excavation provision was made for a unit price payment for "earth excavation." Earth was defined "the word earth when used in these specifications, shall mean all kinds of materials, including old masonry, excated or which are to be excavated."

Change in Conditions

Should the contractor encounter, or the government discover, during the progress of the work, sub-surface and (or) latent conditions at the site materially differing from those shown on the drawings or indicated in the specifications, the attention of the contracting officer shall be called immediately to such conditions before they are disturbed. The contracting officer shall thereupon investigate the conditions and if he finds that they materially differ from those shown on the drawings or indicated in the specifications, he shall at once, with the written approval of the head of the department or his representative make such changes in the drawings and (or) specifications, as he may find necessary, and any increase or decrease of cost and (or) difference in time resulting from such changes shall be adjusted as provided in Article 3 of this contract.

Changes in Plans

The contracting officer may at any time, by a written order, and without notice to the sureties, make changes in the drawings and (or) specifications of this contract and within the general scope thereof. If such changes cause an increase or decrease in the amount due under this contract, or in the time required for its performance, an equitable adjustment shall be made and the contract shall be modified in writing accordingly. No change involving an estimated increase or decrease of more than $500 shall be ordered unless approved in writing by the head of the department or his duly authorized representative. Any claim for adjustment under this article must be asserted within ten days from the date the change is ordered, unless the contracting officer shall for proper cause extend such time, and if the parties can not agree upon the adjustment the dispute shall be determined as provided in Article 15 hereof. But nothing provided in this article shall excuse the contractor from proceeding with the prosecution of the work so changed.

The court held that the terms "earth excavation" used in construction contracts does not ordinarily mean rock or hard materials, but only includes clay, gravel, loam and the like as distinguished from firm rock. It was held that when the contractor encountered shale rock and limestone and had to excavate those materials at greater expense than earth, the increased expense was allowable as extra.

In another case of a contract with a municipality involving excavation it was held that a provision permitting the engineer of the municipality to increase or diminisn the quantities to any extent must be construed as meaning an increase or diminution within ordinary and reasonable limits and not as authorizing elimination of more than half of the work contracted for. It was held that if municipal corporations may enter into contracts calling for definite construction and are then permitted to reduce or increase the amount of construction to any extent they see fit, all the safeguards thrown around the making of such contracts become futile; the contract can only be let at an excessive figure, because no contractor can tell how many men or how much equipment he would be called upon to furnish.

Where a bulkhead was to be built and dredged material deposited therein and the contractor warned the officer in charge that the bulkhead was not strong enough to withstand the pressure of the material to be deposited in it, but his protests were unheeded and the bulkhead broke, he was held to be entitled to the reasonable value of the services and materials furnished because, it was said, that he did not agree in his contract to suffer any and all losses which might occur by reason of mistakes of supervising officers or to bear losses which occurred by reason of defects in plans which he was directed to use.

An extreme case was decided by a United States Circuit Court of Appeals in a very able decision, where a contract was entered into at a unit price for the construction of a dam, and one item was for cut-stone masonry at $12.40 per cu.yd., estimated by the city engineer to amount to 10 cu.yd., which amounted in value to $124. The contractor was required to construct 865 cu.yd. It was held that it would be unreasonable to hold the contractor for such enormous disproportion at such an inadequate price and that the contractor was allowed to recover a reasonable price, found in that case to be $30 per cu.yd.

Decisions on methods

Sometimes a description of the methods to be employed in carrying out a contract, particularly for excavation, affords a guide to the obligation of the contractor.

Where definite lines of excavation have been established and the contractors have drilled and blasted to the grade limits of the excavation and are then required to go deeper, and by more expensive methods, such as chiseling, are required to excavate to a greater depth than required by the contract, such work is sometimes held

not to be properly speaking "rock excavation" but "rock cutting" entitled to be paid for as extra at a higher price than that provided by the original contract.

Still more decisive as a controlling description of methods was a case involving a very large contract with a county for the construction of a tunnel. It was specified in the contract that it might be necessary in some part of the tunnel to use compressed air as distinguished from free air. It turned out that free air could be used in only a small part of the construction work and that for nearly the entire length of the tunnel the use of compressed air was necessary and it was required by the engineer for the county in charge of the construction. It was held by a U. S. Circuit Court of Appeals that this description of methods was controlling and meant that free air could be used in most of the tunnel and that compressed air would be required in only a comparatively small portion of it. The use of compressed air for nearly the entire length of the tunnel gave rise to a claim for extras which was held to be valid to the extent of half a million dollars.

Presentation of claim

It is generally required by contracts for construction that the contractor must present his claim in writing to the designated officer to entitle him to payment for extra work. Generally a claim must be so presented to entitle the contractor to be paid by judgment of a court.

It has sometimes been held that where the supervising engineer has already ruled in advance against the contractor, the presentation of the claim is excused as a futile and useless act. It is always safe, however, to present a claim in the manner pointed out by the contract.

From what has been stated it will be seen that while those entering into contracts for construction are bound by the language of their obligations, the courts protect them from radical changes under the guise of mere detail alterations allowed by the contract.

But the contractor must help himself and he can do so if he will adopt a few safe rules for guidance. They are set down here in a form that is easily consulted and copied for his field superintendents.

Heavy Pipe Placed by Gantry

THE DISTRIBUTION SYSTEM of the Metropolitan Water District of Southern California includes a pipe line made up of precast concrete sections with an inside diameter of 11 ft. 8 in. The sections are 12 ft. long, weigh about 37 tons each and are cast in a centrally located yard, whence transportation to the trench is on a heavy-duty trailer. Placement in the trench is accomplished by means of a gantry spanning the trench and resting upon T-rails and ties on either side along which its propels itself as the work progresses. A gasoline engine mounted on top of the gantry provides motive power for moving and for handling the pipe sections.

When the trailer is spotted at one end of the gantry a steel cable is passed around the pipe section, the gantry car is moved out to the track end near the trailer, the section is rolled on to the car and the car is moved to the center of the gantry. When the pipe section is lifted the car is rolled back out of the way and the section is lowered into the trench.

Prior to the placement of each section the trench bottom is carefully prepared and compacted so that the bed is accurately finished and leveled to grade before the section arrives. When delivered to exact position, jacks and struts to both sides of the trench are used to hold it in place. These temporary supports remain while the next section is being delivered and until placement of the concrete cradle which embeds the lower portion of the pipe. So effectively has this gantry functioned that where trench conditions were favorable the rate of progress has been placement of 21 sections per 8-hour shift.

In some locations it has been necessary to shore the trench and in wet weather the heavy loads on the adjoining bank have made it difficult to hold the trench sides in soft formation.

Contract on this portion of the aqueduct distribution system is held by the J. F. Shea Co., Inc.

PRECAST CONCRETE PIPES 11 ft. 8 in. in diameter were placed by this rig at the rate of 21 sections per 8-hour shift.

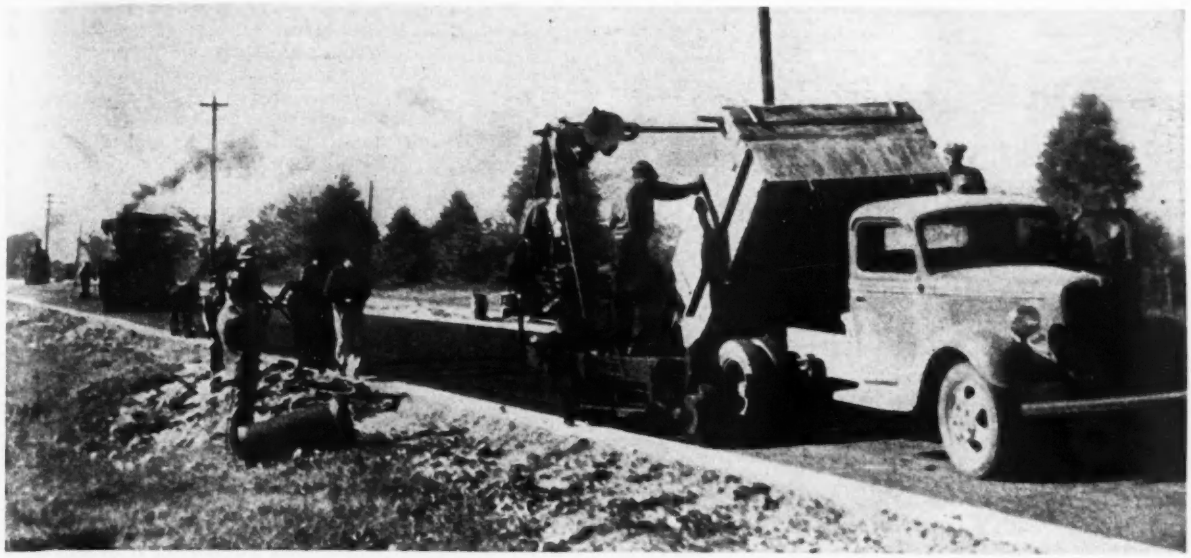


FIG. 1—**ASPHALT RESURFACING** of old concrete pavement placed mostly by night using a finishing machine equipped with electric lights.

Modernizing an Old Concrete Road With Maximum Salvage

Badly broken old pavement made to give the limit of reservice by widening and resurfacing; both asphalt and concrete topping were successfully employed

By V. B. Saville

Engineer of Special Assignments, Missouri Highway Department, Jefferson City, Mo.

IN NONE *of its applications in engineering does modernization indicate so great a fundamental change as in roadbuilding. A modernized road is a redesigned and rebuilt road including only some parts of the old structure. The included old parts may be a few or many but always their position is that of salvage; in all its transport functions the modernized road is a new road. The work of modernization described in the following article is an excellent example. The range of methods employed is wide and these methods offer many suggestions to the practical roadbuilder.*

—EDITOR.

TWO RECENT resurfacing operations by the Missouri State Highway Department are examples of how road modernization can be handled to obtain maximum value from the old structure. The work consisted of resurfacing and widening an old concrete pavement on U. S. Route 40, in Callaway and Montgomery counties. One operation was portland-cement concrete resurfacing and widening; the other was asphaltic-concrete resurfacing with portland-cement concrete and asphaltic-concrete widening. The original pavement was a 9-6-9-in. non-reinforced portland-cement concrete slab which had prematurely failed extensively due to a subgrade of poor supporting power, aggregates of inferior quality, lack of modern proportioning practice and perhaps other less important reasons. This pavement carried a traffic of about 2,000 vehicles a day.

Road redesigned

Portland-cement concrete and asphaltic concrete were selected as the two materials with which to reconstruct the old pavement, as this afforded an opportunity to study the relative merits of the two for application on future work. While each type of resurfacing was individually designed and constructed, there are certain features that are common to both.

The width of right-of-way is increased from 60 ft. to 150 ft. and the width of the pavement is increased from 18 ft. to 22 ft. Horizontal curves are changed from an 8-deg. maximum to a 5-deg. maximum. In computing super-elevation by the formula

$$S = \frac{0.067\ V^2}{R}$$

V is changed from 25 m.p.h., as used originally, to 35 m.p.h.

Drop inlets to remove surface water from the pavement were selected in preference to open side drains that would cut across the shoulder and increase the over-run hazard; also this design permitted drain construction before the shoulders were widened as noted later. These inlets are of three types: Type A has an opening on each side of the pavement and receives drainage into a common across-road channel and discharges into the most convenient side ditch; Type B contains a single inlet and discharges into the nearest side ditch and Type C is installed directly above culverts and discharges into them through a vertical connection. Typical details of Type

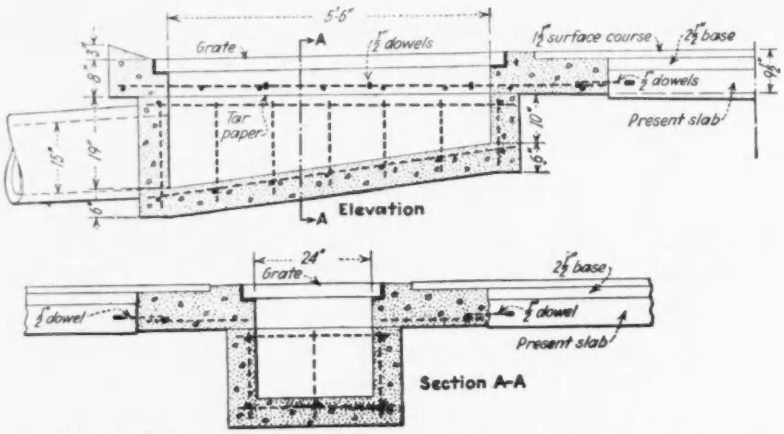


FIG. 2—DROP INLETS for pavement drainage were used throughout; the drawings show a single-entrance inlet but two other styles were also used.

B are shown by Figs. 2 and 3; Type A is similar in design except for overall dimensions, and Type C is identical except for the outlet through the bottom. The designs are the same on the concrete resurfacing except for minor details.

Shoulders and ditches were improved to increase the safety of traffic that might be forced to leave the pavement. Fig. 4 shows the planned cross-profile of the roadway. The shoulder width is increased from 6 to 10 ft.; the ditches are from 2 ft. to 3 ft. below the point of the shoulder and from 33 ft. to 39 ft. from the centerline of the roadway. Since adequate right-of-way was not then available shoulder construction was not included in the contracts for resurfacing but was postponed until right-of-way could be purchased. The rapid rate at which the old pavement was failing made necessary the immediate reconstruction of the surface without awaiting the acquisition of increased right-of-way. A contract time of three months was stipulated to hold to a minimum the inconvenience to traffic made necessary by a long detour which was required during construction.

Asphaltic-concrete resurfacing

The asphaltic-concrete resurfacing consists of an asphaltic-concrete binder and leveling course of variable thickness, an asphaltic-concrete surface course, portland-cement concrete widening except for a short test section, repairs to the old broken pavement, drain tile where necessary, drop inlets, curve realignment and other items of minor importance. Typical cross-sections of the pavement under various conditions of alignment and presence of old surface are illustrated in Fig. 6. Plans for the drain tile are shown in Fig. 5. Both portland cement concrete and asphaltic concrete widening were used so as to study their relative suitability in this type of work. The length of the project is 6.28 mi.

FIG. 3—THE GRATES of the drop inlets present an unusual feature in a rural paved road; the view is on a concrete resurfaced section of old concrete road.

The general sequence of construction operations was to place the underdrains; break up and remove that portion of the base which needed repairs; cut openings for the drop inlets and drains; build the widenings and drop-inlets, and finally the asphaltic concrete resurfacing. This sequence indicates generally the order of starting the several steps but many of the operations were carried on simultaneously. The excavation for the underdrains, widening and drop inlets was done by hand. Drilling was necessary to anchor the concrete curb and drop inlets to the old slab and to outline openings in the pavement for inlets or underdrains. Holes were drilled at 10-ft. intervals in the old slab to anchor the inside wooden curb form and to hold the outside metal forms wherever it was necessary to set them on the old slab. A pavement breaker broke the old concrete along the lines marked by the drill holes for the drop inlets and underdrains and also broke up small slabs of the old pavement, which had become tilted or displaced under traffic, to permit ready removal.

Forms were set and concrete was poured in the widenings immediately following the excavation and drilling. The outside form (a 9-in. paving form) was set to grade. The inner form of wood was fastened to the old pavement by bolts which were anchored in the slab. The depth of the wood form was variable because of the irregular surface of the old pavement. Concrete for widening was proportioned and mixed in regular paving equipment operating on the grade. On a small part of the work the concrete was wet-batched to the job but this was found undesirable because a rough haul road and open truck beds promoted segregation. The lip on the widening was built integrally by the use of an auxiliary form attached to the regular form; a templet shaped the lip to the proper section. The concrete was puddled and floated with hand tools. On curves where the new slab left the old pavement the new concrete base extended the full width of the pavement as shown in Fig. 6.

A part of the aggregate was obtained from a local quarry, but because this plant was unable to produce an aggregate of balanced gradation for asphaltic concrete it was necessary to supply selected sizes from other sources. The aggregates were delivered to the plant separated into sizes which would enable the contractor to change from base mixture to top mixture without requiring a change of asphaltic-plant screens—an operation which would have required several hours delay.

The asphaltic concrete was produced in a modern Hetherington-Berner plant (Fig. 7) equipped with a 3,500-lb. pug-mill mixer, a triple-deck vibrator screen and a mechanical arrangement for handling mineral filler. The aggre-

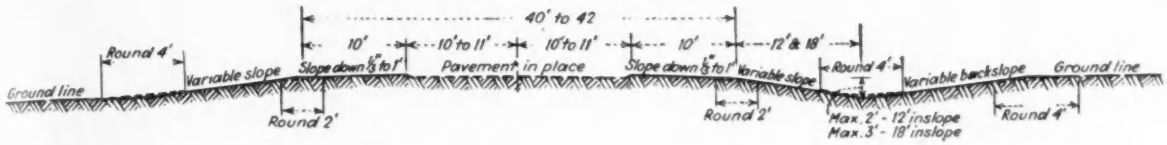


FIG. 4—MODERNIZING meant a transverse profile greatly widened and having flat slopes on shoulders, ditches and banks.

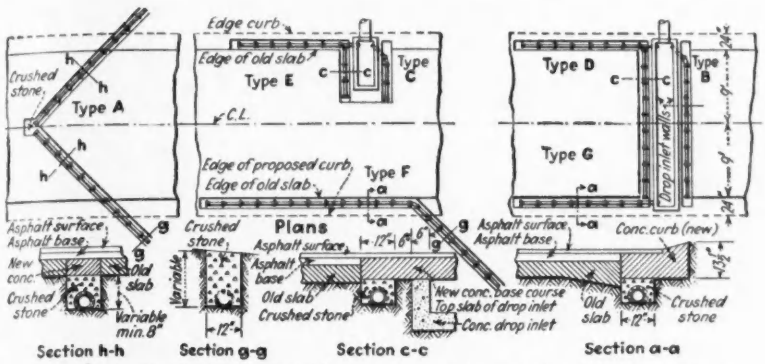


FIG. 5—PIPE SUBGRADE DRAINS of various types were liberally used at drop inlets and other locations where such relief was required.

TYPICAL ASPHALT MIXES USED IN RESURFACING AND WIDENING OLD CONCRETE PAVEMENT IN MISSOURI

	Surface A Per cent	Surface B Per cent	Base Per cent	Sub-Base Per cent
Passing 2½ in. screen, ret. on 1½ in. screen	.....	.....	.....	8.2
Passing 1½ in. screen, ret. on 1½ in. screen	.....	.....	14.6	15.9
Passing 1 in. screen, ret. on ¾ in. screen	.....	.....	13.4	17.7
Passing ¾ in. screen, ret. on ½ in. screen	1.9	1.0	12.0	
Passing ½ in. screen, ret. on ¼ in. screen	24.4	27.7	15.1	18.6
Passing ¼ in. screen, ret. on 10 sieve	31.0	38.0	16.9	17.2
Passing 10 sieve, ret. on 40 sieve	19.3	17.5	11.5	
Passing 40 sieve, ret. on 80 sieve	7.6	3.6	6.8	5.7
Passing 80 sieve, ret. on 200 sieve	3.6	2.0	3.0	
Passing 200 sieve	6.7	4.2	2.2	2.6
Asphaltic cement	.....	.....	4.5	4.0

Note.— Screens had round openings.

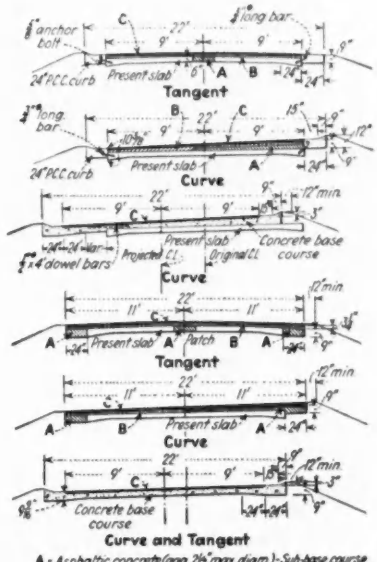


FIG. 6—STRAIGHTENING and widening the old road and banking the curves called for a variety of asphalt resurfacing sections in salvaging the old pavement.

gate was dried in two driers of 50-ton capacity each and was fed into the driers by a double feeder bin especially equipped to feed four different sizes of aggregate. A locomotive crane with a 1½-cu. yd. bucket moved the aggregates from storage piles to the feeder bin. Control of the mix was supervised by inspectors who constantly checked the batch weights and made other tests and observations at frequent intervals. A report was submitted daily by the inspector showing the typical mix conditions which existed during the day, and with it charts from the recording pyrometer which indicated the temperature conditions of the materials entering into the mix.

Typical mixes used on the work are shown in the accompanying table. Two mixtures, designated as A and B in the table, were used in the surface course. The alternate types were employed to permit a study of the influence upon resistance to skidding which might result from the difference in surface texture.

The mixture was spread on the grade by a paver, Fig. 1, supplemented by hand finishing. It was consolidated by rolling with a 10-ton 3-wheel roller and a 10-ton tandem roller. During a portion of the time the contractor operated a night shift, but laying operations during this shift were confined to the construction of sub-base and base since better light was required for the proper construction of the surface. On sections of great thickness the mixture was spread and rolled in successive layers until the proper grade had been reached. Ramps were used to raise the finishing machine and rollers over the drop inlets in laying the lower courses; the mixture around these obstructions was consolidated by hand tamping.

There were employed 108,000 man hours of labor with a maximum payroll of 370 men daily, of which 25 were carpenters employed in form building. The materials used included 10,700 anchor bolts, 90,000 gal. asphalt, 8,900 bbl. cement, 57 tons reinforcing steel, various aggregates of different sizes, 8,700 f.b.m. of form lumber and other sundry materials. The presence of the drain basins which were built at an early stage greatly impeded progress on subsequent portions of the work due to their interference with the transportation of materials and inconvenience in placing the asphaltic mixture. Concrete used in miscellaneous sections was paid for on the basis of theoretical volume and asphaltic mixture was paid for by the ton. Asphaltic widening harmonized more readily with the construction of other portions of the work than did portland-cement-concrete widening.

Cement concrete resurfacing

The concrete resurfacing consists of a slab having a minimum thickness of 4 in. with widening, curve realignment, drop inlets and other improvements of minor importance. The total length is 11.74 mi. Typical cross-sections of the resurfacing are shown by Fig. 8 and plans for the transverse expansion joint

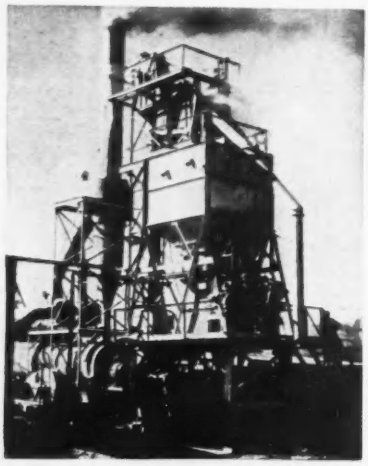


FIG. 7—HOT MIX for the asphalt resurfacing was produced at a modern asphalt paving plant having a capacity of 65 tons an hour; trucks shown by Fig. 1 hauled the mix to the paver.

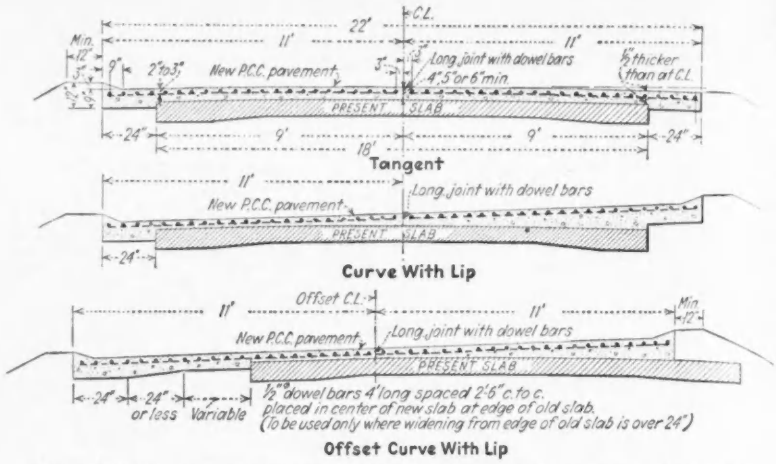


FIG. 8—CONCRETE RESURFACING like asphalt resurfacing (Fig. 6) called for a variety of sections to fit and embody the old pavement.

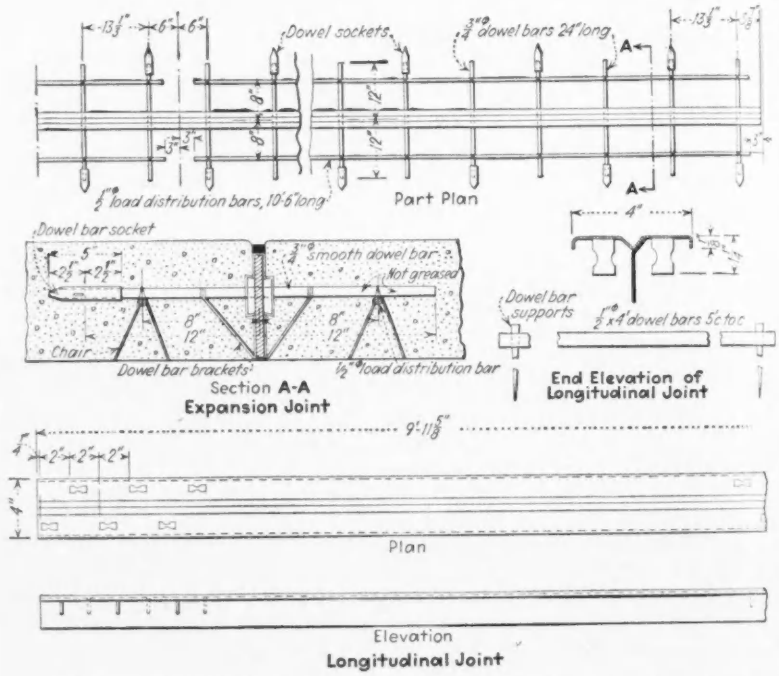


FIG. 9—EXPANSION JOINTS and center joints for the concrete resurfacing are of a design that is uncommon.

and the longitundinal joint are shown by Fig. 9. The thickness of the resurfacing varies between 4 in. and 6 in., the greater thickness being used over sections of badly broken base or subgrade of questionable supporting power and when necessary to remove slight irregularities in the base.

The first stages in construction were: excavation along the old slab, drilling holes outlining the excavation for drop inlets and drilling holes in the proper location to support transverse joints and side forms during construction. The fine grading for the paving forms was done by hand and the remainder with blade graders. Holes were drilled in the old pavement to outline the areas to be excavated for drain basins and to create planes weakness so that the old pavement might be easily broken. Holes at the transverse joints were to receive pins which held the joint assembly in place during pavement construction. Holes for form pins were necessary on curve relocation where the edge of the new slab rested upon the old.

The forms were set and, with the exception of expansion joint assemblies, the concrete was poured and finished in accord with conventional methods and equipment. To increase the efficiency of his paving equipment the contractor handled his cement in bulk which enabled him to use batches equivalent in size to the maximum capacity of his 27E paver.

Due to lack of uniform depth of the new slab it was necessary to assemble the expansion joints on the grade. A rigid wooden template equipped with pins protruding at 12-in. intervals from a surface cut to conform to the surface of the new pavement was used to determine the cross-section of the pavement at each point where a transverse joint was to be constructed. The pins were ½ in. deformed reinforcing bars which were held in place by friction. The template was set on the side forms and the bars driven down to contact the subgrade or old pavement. A pattern was thereby provided by which the premolded joint material could be cut to accurate dimensions. The joint was assembled with various materials on the grade, installed in the regular manner and held in place during construction by pins driven into holes provided in the old base.

The drop inlets on this work were constructed behind the paving operations. A 20-ft. strip of pavement was omitted by the paving crew at each inlet. Another crew followed the paver and made the necessary excavation, built the drop inlets and the 20-ft. gap in the pavement. This crew used a two-bag mixer, wheelbarrows and platform scales for preparing the concrete and hand tools in finishing the slab.

The mix used in the concrete surface consisted of 1 part cement, 2.546 parts fine aggregate and 3.895 parts of coarse aggregate expressed in absolute volumes. The cement factor was about 1.54 bbl. per cu. yd. of concrete. The average flexural strength of the resulting concrete was 590 lb. per sq. in. in three days.

Several items of interest concerning progress and quantities were noted:

The job required 134,500 man hours of labor with an average payroll of 200 men per shift, two 8-hour shifts per day and five days per week on most of the job. The pavement required 28,800 cu. yd. of concrete and 46.5 tons of steel grates and bearing plates. The contractor made excellent progress receiving notice to proceed on July 6, 1936, and finishing Oct. 16, operating his paver on 57 days, laying a maximum of 2,076 lin. ft. in one day with an average of 1,087 lin. ft. per day. Concrete in the resurfacing was paid for by the cubic yard. Shoulder work on both projects consisted of moving enough dirt against the edges of the pavement to protect it. No attempt was made to handle vehicles on the shoulder.

The completed projects present an excellent surface for traffic and with the completion of the shouldering, which is anticipated within the next six months, should provide a highway of relatively great safety for high-speed two-lane traffic. The prospects are that these two types of construction will be in popular use in Missouri for resurfacing old concrete pavements in the future where traffic volume will warrant.

Severe Damage to Outfall Sewer Caused by Action of Acids

After 14 years, first inspection of a large sewer shows much of the cement mortar destroyed, spalling of tile liners and some cracking

A HAZARDOUS 6-mile inspection trip through the north outfall sewer in Los Angeles developed the fact that cement mortar in the tile liner joints had disintegrated, that liners had spalled off in many places and that there was cracking. More detailed examinations of the most seriously damaged portions are to be made and repairs will be made. Equipment and methods used in making the inspection were described in *Engineering News-Record,* Sept. 10, 1936, p. 379.

This portion of the Los Angeles sewer system was built in 1922 since when there has been no inspection of the interior other than observations from the few manholes. As a result of surface indications of leakage, external concrete blankets were placed a few years ago on some parts of the sewer. On recommendation of the city engineer the city council last year appropriated a total of $3,000 for material, equipment, special insurance, etc., necessary to making the 6-mile inspection, with the result that much information was obtained as to disintegration under the attack of sewer gases.

The 31,092-ft. length of the north outfall sewer that was examined extends from the Centinela siphon on the upper end to the screening plant at Hyperion where sewage is discharged into the ocean. The outfall is an unreinforced, semi-elliptical concrete sewer 10½ ft. high with a maximum width of 12 ft. 3 in. Above the spring line the interior was lined with vitrified clay lining blocks 9 in. wide by 18 in. long. Because of the great length of many of the tributary lines, the sewage is highly septic in this portion of the system.

For a length of about 14,000 ft. just above the screening plant where conditions were found to be "as good as could be expected," the report recorded was: "The cement mortar joints between the tile of the arch are firm and hard; on the side walls, however, the joints are soft. There is some spalling and a few tiles are off. No cracks were observed."

In the next 3,500 ft. there are many places where several tiles are off, there is a great deal of spalling, the cement joints generally were found to be soft and there are several transverse cracks. In one section a large longitudinal crack on the south side was found to be about 480 ft. long. This was adjacent to oil wells located near the right-of-way; here the conditions were found to be very bad and worthy of a special investigation.

This section and a considerable length of the line near the upper end showed the worst conditions. For these zones the report reads, "There are a great many tiles off, in many cases the tiles are gone from large areas, the joints are soft, there is heavy spalling and several transverse cracks."

Except near the outlet at Hyperion, the interior of the sewer when first opened up was damp and the side walls carried a heavy yellow growth. On analysis this growth was found to be an alkaline substance containing sulphur trioxide, metallic oxides and calcium oxide.

Conclusions

In analyzing conditions reported, conclusions of the city engineer's staff were that the disintegration is the result of sulphuric acid attacks on the portland cement mortar joints between the clay tile lining blocks and that the sulphuric acid has its origin in the oxidation of hydrogen sulphide gas in the presence of water. As the acid acts upon the mortar, the cement is softened and reduced to gypsum which has a much larger volume than the cement. This increase in volume in the joint material exerts a lateral pressure upon the edges of the tile and causes wedge-shaped pieces to crack off or spall. As the action of the acid penetrates the joints to the back of the tile, the tile lining is entirely broken off, usually leaving the tile lugs embedded in the concrete beneath. The acid attacks then continue, of course, on the unprotected concrete beneath that is exposed by the loss of the tiles.

Whole tiles have not fallen off bodily, as a rule, but have been broken off in pieces as the acid action has progressed. Where a tile is found with only a

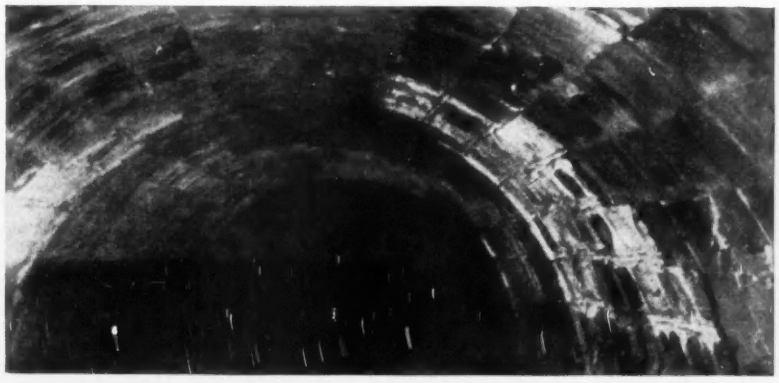


FIG. 1—INTERIOR of the north outfall sewer approaching a horizontal curve. In right foreground tile liners have been spalled off with more loss on the side walls than up toward the crown.

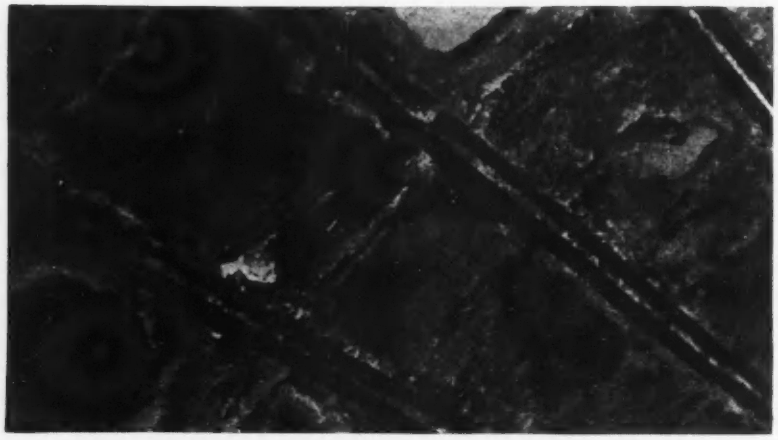


FIG. 2—UNPROTECTED concrete after tile liners have entirely spalled off, leaving only the tile lugs embedded in the concrete.

small portion spalled off the remainder of the tile is not loose and gives out a solid sound when tapped.

Cement joints between tiles on the side walls where daily flow variations cause them to be alternately submerged and exposed, usually are attacked first. The disintegration progresses thence upward. The crown of the arch, which is seldom submerged, is affected last.

The sewer grade is greater in the horizontal curves than on the tangents between them. At the end of horizontal curves where the steeper grade of the curve intersects the flatter grade of the tangent, the sewage flow is turbulent and here invariably there is indication of deterioration caused by the release of hydrogen sulphide gas. Decided deterioration also occurs at siphon inlet and outlet where turbulence always occurs.

In addition to Los Angeles sewage this outfall also carries sewage from sixteen other cities and districts which have contracted with Los Angeles for sewage disposal. Because of the importance of prolonging the useful life of the outfall and before its condition becomes dangerous, it is planned to sink shafts for exterior inspection in those zones where major cracks or other serious deterioration has occurred. Also certain of the brick manholes are to be reconstructed and further studies are to be made looking to such means of repair and further protection of the outfall lining as may be feasible.

This work is being conducted under the direction of Lloyd Aldrich, city engineer of Los Angeles.

Collapsible Forms for Concrete Used in Flat-Arched Conduit

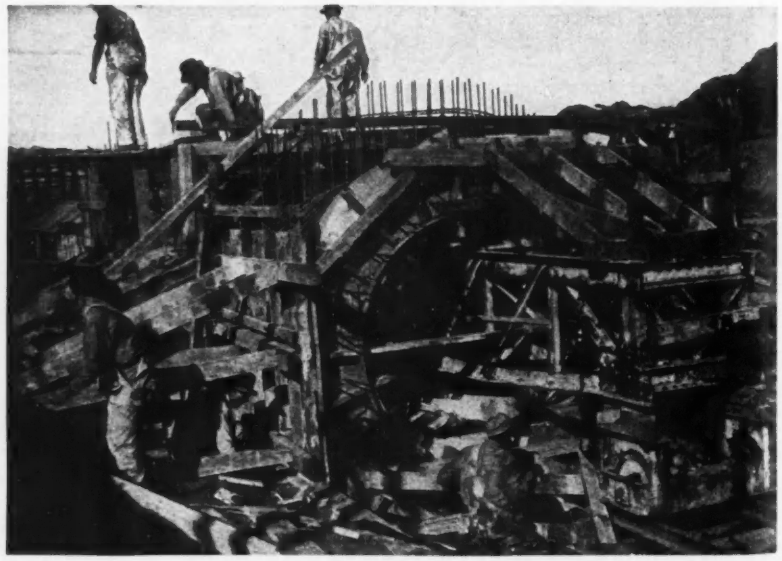
CONSTRUCTION of the sludge pipe galleries beneath the desilting plant at Imperial Dam involves a rather unusual requirement in that the width of each gallery increases toward the downstream end and thus flat portions of the perimeter in both arch and invert are of constantly changing width. Six of these sludge galleries are required, each with a length of about 1,050 ft., to carry the steel pipes in which sediment will move from the desilting plant into the sluiceway. Because the design of the galleries called for curved side walls, the most convenient forms could be made up with steel plates. The need for ingenuity in planning the method of construction arose in the question of how the forms could be designed for speedy and effective moves. The method developed was to use a steel truss support, one end of which is shown in Fig. 1, designed to carry steel form panels built up in sections and hinged as shown in Fig. 2.

The steel truss, rectangular in cross-section, is 43 ft. long. The rear end is supported on a track laid on the finished surface of previously poured invert. The forward end is carried by a track in the excavation, as shown. The steel forms are made up in three sections with a total length of 31 ft. 3 in. On tangents the three sections are bolted together; on curves they function unbolted, with the inner edges set flush and with the gores between the outer edges filled in with specially fitted wooden fillets.

Since the gallery width varies, the flat portions of the cross-section in arch and invert were made variable so the same curvature could be retained on the sides throughout. The invert is poured without any top form and the gore at the crown of the arch is spanned by a steel plate.

In Fig. 2 the forms are shown in cross-section and it will be noted that a hinge is provided on each side near the center of the upper quadrant. When set up in place the open space for the invert concrete is maintained by steamboat jacks. When a pour has been completed and the forms are to be moved ahead, the lower corners at the edge of the invert are pulled in by the jacks, the steel truss carrying the forms is lowered in its entirety by jacks in the carriages

FIG. 1—STEEL TRUSS projecting from sludge pipe gallery. Note jacks for raising and lowering and winch for moving ahead.



at each end (see Fig. 1) and the entire assembly then is moved ahead on track laid in the bottom of the trench and on the floor of the last completed pour.

The diagonal bracing from the forms to the truss support, as shown in Fig. 1, is to withstand the hydraulic thrust from the end bulkhead. When set in place for a pour the truss is blocked against longitudinal movement such as might develop from thrust.

Forms for the outside of the concrete gallery are built up in wooden panels. Maximum economy of concrete is obtained by using an eight-sided figure (Fig. 2). The subgrade is finished to the shape of the floor and the lower sloping chords. The vertical chords are formed by wooden panels braced to the sides of the excavation at the bottom and tied across the top of the structure.

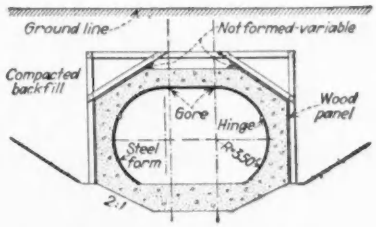


FIG. 2—CROSS-SECTION of the sludge pipe gallery showing variable gores at top and bottom and general arrangement of inside and outside forms.

The sloping chords across the top are formed by lagging put in place as the concrete reaches that elevation.

Concrete is placed firts through doors in the wooden forms near the bottom of the vertical chords. This continues until the invert is completed and concrete is up to door level. Pouring then is continued through vertical spouts to fill the sides; the three top chords are poured through the central opening on top. Concrete is brought by trucks from the mixing plant, dumped into a hopper near the excavation and wheeled in hand buggies to the forms via a platform constructed over them.

The job is being done under contract for the U.S. Bureau of Reclamation.

Belt Conveyor Jumbo Aids in Lining Small Tunnel

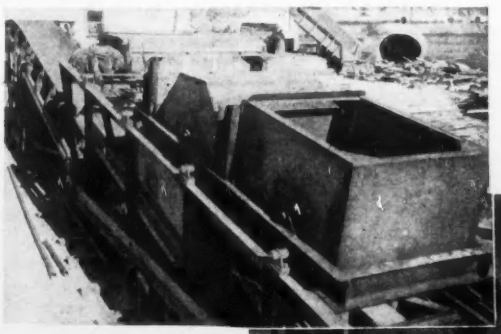
TO SAVE HEADROOM in the relatively small (9-ft. elliptical) Mono Craters tunnel under construction by the Bureau of Water Works & Supply, city of Los Angeles, an ingenious jumbo has been constructed which receives cars containing aggregate or concrete and delivers the contents via conveyor belt to concrete mixer or to concrete placing machine, as may be required. The jumbo itself is about 75 ft. long, is supported on three trucks and is equipped with three electric motors; one drives the conveyor, one advances the jumbo along the track as new set-ups are made and the third pulls loaded cars onto the jumbo so they can discharge to the belt.

The jumbo functions in connection with specially built cars each equipped with two 1-cu.yd. steel containers for carrying dry batches of aggregates or ready-mixed concrete. These cars have two parts, a four-wheeled truck and a detachable chassis which may be slid bodily off the truck, carrying with it the two containers. When the loaded car reaches the rear of the jumbo a hook is attached at the forward end and the upper part of the framework with the two batch boxes is pulled up an incline on the jumbo. The incline consists of a row of wheels that engage channel irons on the sides of the chassis.

Each batch box has trunnion supports about which it can be rotated to discharge its contents to the lower end of the belt conveyor. The belt is inclined at such an angle that the forward end can discharge concrete (or aggregate) to concrete mixer or to pneumatic gun.

With this equipment in the tunnel, materials for the concrete lining come in in the usual manner and, despite the limited headroom, are delivered quickly and effectively into the concrete handling equipment. The design was made to accommodate either dry materials or mixed concrete because for the short hauls during which only a little time would elapse in transit from the portal to point of delivery in the tunnel it was more economical to use concrete mixed in the mixing plant at the portal. For the longer hauls and where possible delays in delivery in the tunnel become a factor, a concrete mixer will be used between the discharge end of the conveyor belt and the pneumatic placing unit so that the mixing of the concrete can be carried on in the tunnel. Then only dry aggregates will be transported.

H. A. VanNorman is general manager and chief engineer of the Bureau of Water Works & Supply. The special jumbo was designed and built under the supervision of S. M. Dunn.



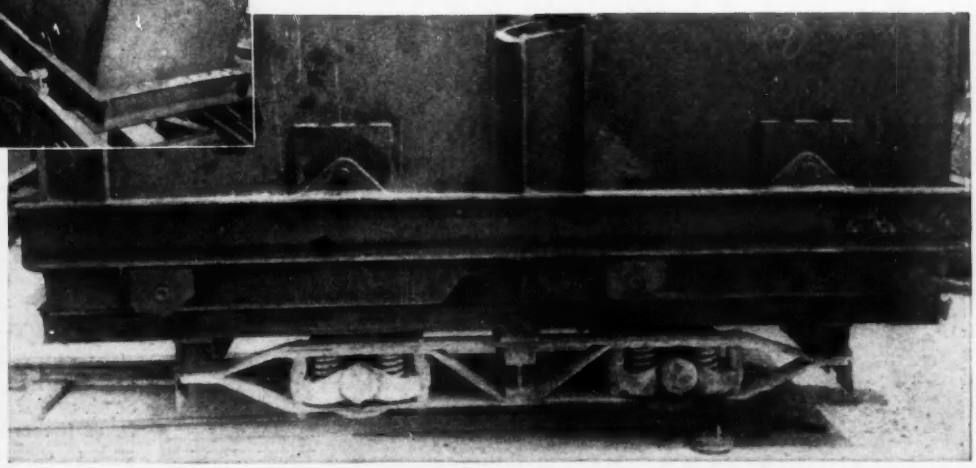


FIG. 1—JUMBO for use in tunnel lining has an inclined conveyor belt fed by batch boxes that rotate on trunnion. Below, batch boxes are shown mounted on a special chassis designed to be rolled off the truck on which it is transported into the tunnel and to ride up a row of inclined wheels on the conveyor jumbo. Wheels on the jumbo engage channel irons on the sliding chassis.

Widening an Ancient Stone Bridge For Modern Traffic

Iena Bridge in Paris, 122 years old, doubled in width by new arches outside the old bridge and connected with it by steel floorbeams

SIXTY YEARS AGO when the Iena Bridge over the Seine in Paris was 64 years old, the Eiffel Tower was built at one end of it and the Trocadero Gardens and Palace at the other, the two forming the most conspicuous elements of the Exposition of 1878. Next month the Exposition of 1937 will open, and these two structures again will dominate the scene, still joined by the Iena Bridge. In appearance, the 122-year old stone arch bridge is unchanged. Its usefulness, on the other hand, has been greatly increased by doubling the width of its deck. Behind this modernization job is a construction operation of special interest.

As built in 1814, to commemorate a famous victory of Napoleon I, the Iena bridge was 49 ft. wide and consisted of five stone arches of 92 ft. span and 12 ft. 3 in. rise. The new wider bridge is obtained simply by building new reinforced concrete arches 11½ ft. wide on each side of the arches of the existing bridge and spanning the resulting spaces with steel floorbeams. The new foundations are entirely separate from the old. A deck width of 114½ ft. results, providing a 72-ft. roadway and two 21 ft. 3 in. sidewalks.

The poor bearing quality of the river bottom material made pile foundations mandatory as they were on the original bridge. Under each new pier 32 concrete piles 14-in. square were driven to a depth of 23 ft., giving a bearing capacity per pile of 70 tons. The piles were driven within a cofferdam composed of copper-bearing steel sheetpile walls. The wall on the upstream side was left in to resist scour while the other three walls were withdrawn after the work was completed. The abutments are mass concrete structures supported on 35 and 42 reinforced concrete piles, respectively. The abutments and piers which rise 14 ft. 7 in. to the springing line of the arches are faced with stone 16 in. thick which was utilized as the outside form for the concrete—Fig. 1.

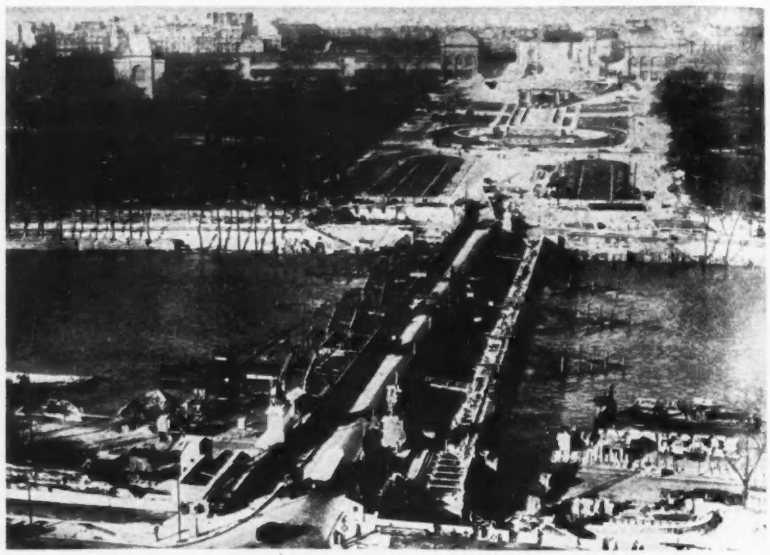
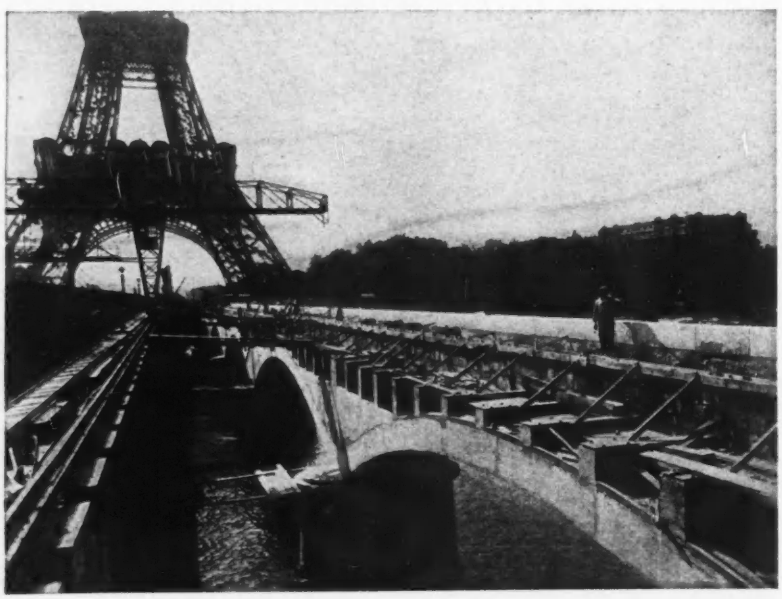


FIG. 2—CONSTRUCTING new arches either side of Iena Bridge in Paris to permit widening the deck from 49 to 115 ft. Steel arches at left are centering for concrete forms. A transporter bridge handles materials from trucks on the roadway to the arches under construction. In background, Trocadero Palace is being rebuilt for Paris Exposition next month.

FIG. 1—READY FOR STEEL FLOORBEAMS that will join new arch at right with original bridge at left. Eiffel Tower provides an effective portal for the modernized bridge.

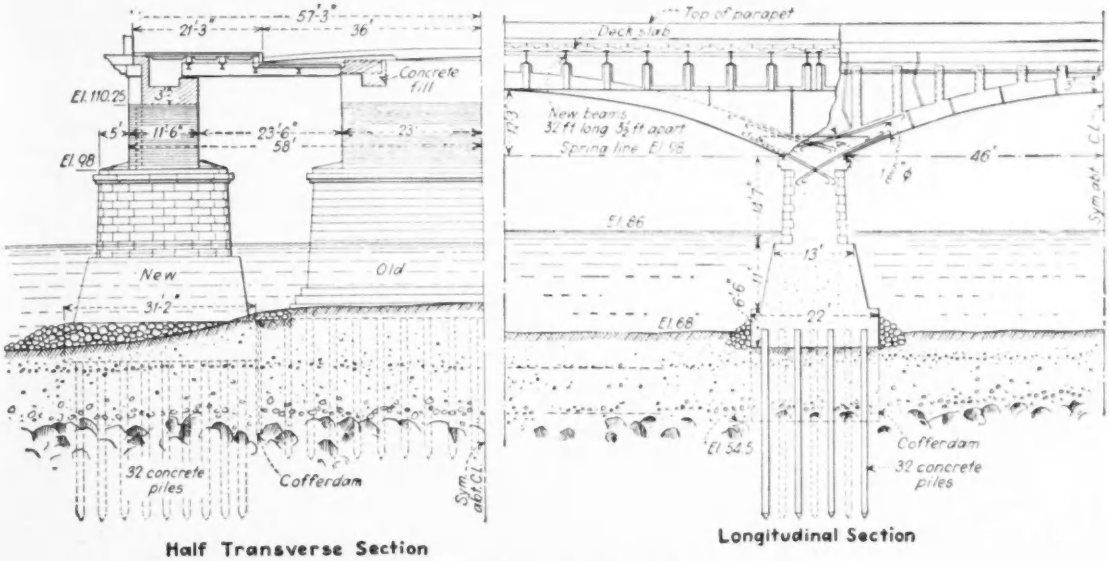


Steel arch falsework

The regulations of the highway board (Ponts et Chaussees) do not permit the use of timber centering during wintertime when there is possibility of heavy floods. Four steel arch centers (each used twice) were therefore designed. These were composed of two steel arch trusses braced by transverse members and carried on the piers. Transverse beams set in the plane of the lower chords of the arches carried steel plates upon which the forms for the arch barrel were laid. At the piers the arch centering rested on sand jacks which were lowered to remove the centering. Bags of sand and gravel hung from the arch centering increased its stability and aided in the control of deflections during the pouring of the concrete. As pouring advanced, the bags were shifted to avoid eccentric loading.

The arch ribs

The new reinforced concrete arch ribs are 11½ ft. wide and have an overall depth of 4 ft. at the springing line and 3 ft. at the crown. The sections at the ends of each arch rib, forming the um-



Half Transverse Section

Longitudinal Section

FIG. 3—NEW ARCHES are entirely independent of old bridge, the only connection being through the steel floorbeams. Arch ribs are unreinforced except over piers.

brellas over the piers, are heavily reinforced with top and bottom bars of 1⅜ in. diameter. The remainder of each rib is made up of 8 unreinforced concrete segments, the joints between these segments consisting of a rich concrete having a strength of 9,000 lb. per sq.in. The external side of the rib keys into the facing stone while on the inside, blocks are provided to support the floorbeams.

The concrete mix for each cubic yard of concrete consisted of 670 lb. of cement, 22 cu.ft. of gravel and 11 cu.ft. of sand. All concrete was vibrated.

The 23½-ft. spaces between the new arches and the old bridge are spanned by riveted plate girders 26 ft. 2 in. long. The girders, 6 ft. 9 in. apart, are simply supported, and in the longitudinal direction are braced by four stringers, two under the sidewalk, one under the curb and one under the roadway. The girders transmit their loads to the arches through reinforced concrete blocks which are 3 ft. 2 in. long by 1 ft. 8 in. wide.

The new decking is composed of a reinforced concrete slab of varying thickness and an asphalt wearing surface. Under the new steel girders are suspended galleries where water, gas, air and other pipes are carried.

The work was designed by the Ponts et Chaussees under the direction of Mr. Gaspard, chief engineer and director of the Seine navigation. The resident engineer was Mr. Morane. The contract for the work was let to Enterprise J. & J. Combe, Paris.

Installment Tax-Payments Survive in Many Cities

INSTALLMENT PAYMENT of taxes, life-saver to many a city treasury during the past few years, may turn out to be a lasting and useful momento of the depression, according to Carl H. Chatters, executive director of the Municipal Finance Officers' Association. Although keeping records of bit-by-bit tax payments brings the city added costs in clerical work, many finance officers report general approval of the plan because it makes the city's financing easier; it benefits the taxpayer, particularly the "little fellow," and it lessens both borrowings and cash balances.

Behind the benefit to the taxpayer lies the theory that the average citizen will more likely bear his taxes and grin if the bill comes oftener, and in smaller amounts, than if it comes in a lump, once a year. The chore of accounting for taxes under the installment plan, in the larger cities especially, is most easily done with machines, Mr. Chatters points out.

Installment payment of taxes dates back over thirty years in Augusta, Ga.; also long-experienced in the practice are Scranton, Pa. and Richmond, Va. With few exceptions tax "installments" have been instituted in the lean years since 1929. The plans have ranged from a semi-annual and quarterly basis to monthly collections, although the latter are infrequent, being too costly to the municipality. Quarterly payments are recommended by finance authorities, with the first one scheduled as near as possible to the beginning of the fiscal year.

At present over forty states have statutes providing for the practically painless plans of tax collection, many of which are optional to cities. It is conservatively estimated that about one-third of the municipalities in states with such laws have established fixed plans providing for payments on the installment basis.

Cities that permit taxpayers to pay their annual bills in ten or twelve installments are Boston, Mass.; Pittsburgh, Pa.; Tampa, Fla.; Somerville, Mass.; Charlotte, N. C.; Kalamazoo, Mich. and Stockton, Calif. Among the cities that have recently adopted the more common quarterly plan are Norfolk and Petersburg, Va., Rochester, N. Y., and a number of New Jersey cities, including Passaic, New Brunswick, Elizabeth and Perth Amboy, are among cities that have recently reported success with the plan after a year's experience. Outremont, Quebec, makes it possible for any taxpayer whose budget will not comfortably bear the whole tax bill at once to petition to pay it by installment. No fines are imposed for delays in payment of taxes other than the interest accruing at 6 per cent from the due date of the taxes imposed.

From Job and Office

Computation of Elliptical Arches

By W. B. Hogan
Babylon, Long Island, N. Y.

OF THE modified arch curves used on highway and parkway grade-separations the 2.2 ellipse

$$\left[\left(\frac{x}{a}\right)^{2.2}+\left(\frac{y}{b}\right)^{2.2}=1\right]$$

is the most common, though it can only be practically computed by logarithms, while the very similar 2.25 equation can be solved by arithmetic.

The useful trigometric relationship between the ratios of the true ellipse

$$\left[\sin^{-1}\left(\frac{x}{a}\right)=\cos^{-1}\frac{y}{b}\right]$$

which permits calculation by parallel tables of natural sines and cosines, is of little help for the computation of the ordinates of a modified elliptical arch. A convenient form for the latter is that shown in the accompanying forms 1, together with a table of 2.2 powers of common abscissas. A quick independent check may be made approximately by the use of form 2, with a graph drawn by plotting values for the curve $[u^{2.2}+v^{2.2}=1]$. If this curve is laid out carefully on a 10x14-in. piece of cross-section paper in the design shown, it can be used to obtain check results to about one-hundredth of a foot on average-size arches.

The area between the horizontal springing line and the soffit on a section of a modified elliptical arch has been calculated to be 0.8129 of the rise times the span for the 2.2 equation. Several determinations of actual arch areas by the trapezoidal method checked close to this value.

These methods were evolved in the bridge department of District 10, New York State Department of Public Works, division of highways. J. J. Darcy is district engineer, J. Gurin, bridge engineer, and P. Goppoldt, designer.

FORMS for solving a 2.2 ellipse by logarithms and by graphical means.

Form 1 - 2.2 Ellipse by Logarithms

Western Parkway
10th St. Grade Separation
Conc. Intrados Ordinates

Span = 60.250
(a) Half Span = 30.125 log 1.4789271 · 2.2 = 3.2536396 log of 1793.245 = $a^{2.2}$
(b) Rise = 12.470 log 1.0958665 − log a = 9.6169394 = log $\frac{b}{a}$

x	$x^{2.2}$	$a^{2.2}-x^{2.2}$	log	times 0.45454545	+ log $\frac{b}{a}$	antilog = y	x
10	158.489	1634.756	3.2134529	1.4606604	1.0775998	11.956	10
20	728.226	1065.019	3.0273573	1.3760715	0.9930109	9.840	20
30	1776.916	16.329	1.2129596	0.5513453	0.1682847	1.473	30

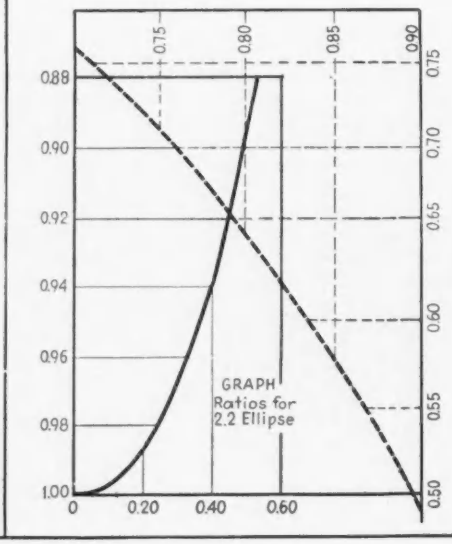
Table of 2.2 Powers

x	$x^{2.2}$
0	0
2	4.595
4	21.112
6	51.515
8	97.006
10	158.489
12	236.700
14	332.263
16	445.722
18	577.563
20	728.226
22	898.111
24	1087.589
25	1189.784
26	1297.004
27	1409.290
28	1526.679
28.5	1587.299
29	1649.209
29.5	1712.412
30	1776.916
30.5	1842.721
31	1909.835
31.5	1978.260
32	2048.000

Form 2 - 2.2 Ellipse from Graph

$\frac{1}{a}$ = 0.033195 b = 12.470

x	$\frac{x}{a}$	$\frac{y}{b}$ (from graph)	y
10	0.3320	0.9588	11.956
20	0.6639	0.7885	9.833
30	0.9959	0.117	1.459



Special Panel Form Staging

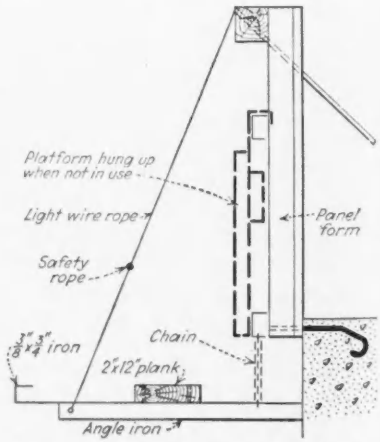
Daniel McFarland
Mason City, Wash.

CONCRETE for Grand Coulee dam is being poured in blocks most of which are 50 ft. high by 25, 40, or 50 ft. wide. The panel forms for these blocks were built in units which reach the full width of the block and are 5 ft. high. These panel forms are held in place in the usual manner with tie rods, bolts, and hairpin anchors.

The stripping crew, and afterward the carpenter crew, have to get at the heads of the bolts at the bottom of the panel. At first a movable staging supported by a light iron fence attached to the top of the panel was used for this purpose, but these could not be left in place when not in use because the concrete bucket would hit them when the adjacent block was being poured. It was a waste of time to move the staging from place to place, so a special staging supported by chain and wire rope was built that could be left attached to the panel and could be folded up out of the way when not in use.

The drawing below shows the construction of the staging; the position of the staging when it is hung up out of the way, by the iron hook at its outer edge, is shown by dash lines.

The details of this staging were worked out by E. R. Stokes, carpenter superintendent, Mason-Walsh-Atkinson-Kier Co. M. H. Slocum is general superintendent for the contractor.



THIS STAGING for work on concrete forms can be hung up against the forms when not in use.

Farm-to-Market Roads Extended By Wisconsin

By Dean B. Ekstrom
WPA State Supervisor, Farm to Market Roads, Madison, Wis.

USING THE MAIN ROADS only as places from which to head off, engineers leading thousands of men are carrying year-around road service to the remote farms and settlements of Wisconsin. In the first year, up to last October, 5,249 mi. of road were straightened, graded or surfaced to higher standards.

The new roads are WPA roads and had their beginning in July 1935, when the state highway commission of Wisconsin prepared to sponsor a statewide "farm-to-market" road program embracing a substantial part of the state's 60,000 miles of secondary roads. At once projects were set up for each of the 71 counties in amounts varying from $44,000 to $494,000 depending on the estimated rural-relief loads and the extent of improvements contemplated in each county. Applications for these projects, submitted to the Works Progress Administration, provided that state highway specifications would be followed wherever applicable. The projects, involving in all a federal cost of $10,000,000 and a sponsor's contribution of about $2,500,000 were approved at Washington with little delay.

With this step taken, the various townships, villages, counties and other agencies desiring to participate in the program, were invited to prepare proposals on standard WPA forms outlining their individual projects. Although approval of blanket projects covering the individual projects already had been obtained by the state highway commission, this additional procedure was observed to secure from the sponsoring agencies definite commitments of contributions of materials, equipment and supervision, and direct acknowledgment of responsibilities, thus relieving the commission of the burden of responsibility and bringing WPA in direct contact with the sponsoring agencies.

Speed gained

The middle of October 1935, saw unprecedented activity; by that time over 6,000 men were engaged on farm-to-market road projects. This activity continued without interruption through winter and summer, in varying degrees due to fluctuations in labor loads resulting from the fact that WPA had acted as a labor reservoir for industry. Thus from a high of 10,000 men in December, 1935, the labor employed on these projects dropped to 5,000 in July, 1936, when many men left WPA for employment in private industry or with other public agencies, to swell again to 22,000 at the peak of the drought-relief program in October, 1936, when thousands of farmers were assigned to road work.

October 15, 1936, marked the completion of approximately one full year of work. A survey was made to ascertain the progress achieved up to that time. As of that date the Works Progress Administration had spent $5,255,960 and the sponsoring agencies $1,642,432 making the total expenditures $6,898,392, of which 76.2 per cent was WPA and 23.8 per cent sponsors' contribution.

Of the federal funds $1,249,000 or 23.8 per cent, was expended for other-than-labor costs, such as materials and construction equipment, while the sponsoring agencies reported expenditures of $1,378,000 or 84 per cent of their total contribution for these items. A total of 5,249 miles of secondary highways was improved at an average cost of $1,314.23 per mile. Other figures

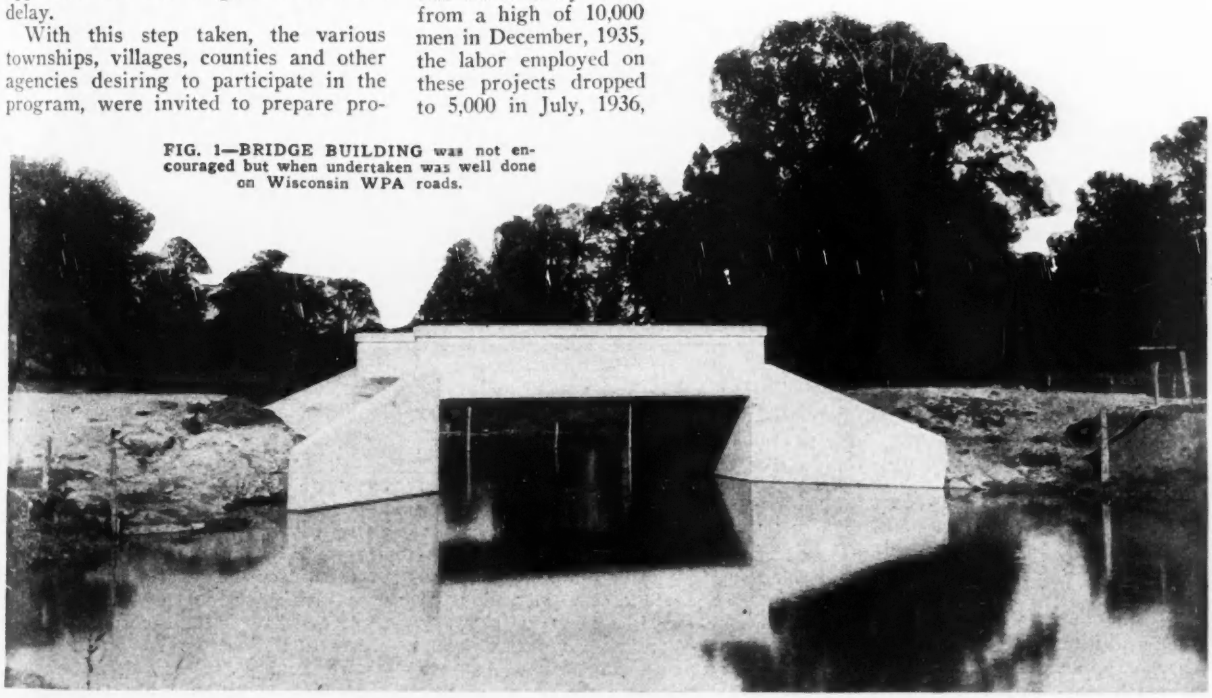


FIG. 1—BRIDGE BUILDING was not encouraged but when undertaken was well done on Wisconsin WPA roads.

FIG. 3—ROAD REHABILITATION in the townships was not as spectacular as some of the county work, but, as this Florence Township road work shows, represented just as constructive a service to rural transport.

developed by this survey are set forth below:

Total cu.yd. grading	5,801,440
Total miles	3,123
Total cu.yd. gravel and crushed stone surfacing	3,370,292
Total miles graveling	4,371
Number of bridges	67
Cu.yd. of concrete in bridges	4,371
Lb. structural steel in bridges	373,370
M ft. b. m. timber in bridges	13.5

The totals for bridges are incomplete; figures for off-take ditches, culverts, riprap, etc. are not available. All told, employment in the amount of 9,700,000 man-hours or about 85,000 man-months was afforded.

There is no disputing that this is a lot of roadwork; the question is: Is the work good? Although too frequently lack of equipment necessitated the use of hand-labor methods that were sometimes ineffective, on many projects the construction standards, methods and costs were found to compare favorably with county and state contract work.

Wherever applicable, Wisconsin highway commission standards and specifications were followed, particularly in bridge and culvert construction, where WPA made their use mandatory. In a few instances complete grading plans and profiles prepared by the state highway commission had been obtained by project sponsors. On the majority of projects, however, the grading consisted of ditching, shouldering and light cuts and fills, making elaborate plans unnecessary. Usually the width of roadway, depth of gravel and other details were determined by the local authorities having jurisdiction, but standard road sections of various widths approved by the Wisconsin highway commission were made available to project foremen and their use whenever feasible was encouraged.

Bridge construction, while not encouraged by the Works Progress Administration has, as a result of local demand, been carried on to a surprising extent, even though it has necesssitated large local contributions for materials.

A review of the work accomplished reveals a wide variety of types of highway construction and construction methods. In many counties emphasis has been placed on surfacing of existing grades with the thought of spreading the improvements over as many miles of road as possible. Much pit run gravel has been used, especially in the northern counties where small relief loads in thinly populated cut-over areas resulted in small labor crews on projects and precluded the hiring of heavy equipment. In the richer and more populated counties more funds, both from sponsors and WPA, were usually available for equipment rentals, and there was more township- and county-owned equipment, with the result that roads were graded to wider sections with improved alignment and grade, and surfaced with gravel or rock crushed to state highway specifications. In some counties practically all unsurfaced roads were surfaced with gravel or crushed limestone.

But general statement presents too vague a picture of how counties and townships grasped the opportunities offered; individual case records give the details more clearly. Obviously only a few can be given but the following have been selected as being fairly representative.

The counties lead

The first case record illustrates a countywide setup under the jurisdiction and control of the county highway commission—the arrangement which has proven to be more satisfactory than a breakdown of the project by townships with each township supplying its own plans and supervision. The account is presented in the words of Chas. E. Moore, county highway commissioner, Rock County, under whose direction

the work was performed. [Rock County is situated on the southern border of the state in the heart of a rich agricultural and industrial section—Editor.]

The Rock County work involved a total cost of $360,000, of which the county contribution of $130,000 provided for the grading; hauling the material onto the road; crushing 30,000 cu.yd. of lime rock, and the gravel and rock royalty. The federal contribution of $230,000 provided for the WPA labor, and for crushing 186,000 cu.yd. of gravel.

The gravel crushing operations started Nov. 13, 1935 and were completed Oct. 19, 1936. The work was operated on an 8-hr. day and the gravel pit equipment consisted of crusher, conveyor, gasoline shovel and loading bin. The crushers were set up with long runways from the pit to the crusher and the material was wheeled up the runways in wheelbarrows. The discharge of crushed material was elevated on a conveyor to the loading bin where it was dumped into the trucks for hauling. The average haul was about four miles. A daily production of 1,000 cu.yd. of crushed rock and crushed gravel was maintained with an average of 275 WPA workmen.

Tractors and blade graders were used to grade the roads and motor patrols were used to smooth the surface and spread the gravel. Plans and specifications were in accordance with the requirements of the Rock County Highway Commission. Each project was supervised by a WPA foreman and he was assisted by a WPA timekeeper. Complete information on the amount of material dumped from the loading bin into the truck and from the truck onto the road was recorded by a weigher and a checker on a record of loads received form. A project report and map of the township giving complete information of the number of men working, cubic yards of material produced, distribution of material and working conditions together with a complete report of the financial status of the entire road program was prepared at the end of each payroll period. The county and WPA road superintendent contacted all road work twice daily and instructed the project foremen on the amount of surfacing required. The development of these secondary highways through federal aid will directly serve 1,600 rural families as well as benefit the whole community. A summary of project costs follows:

Gravel and crushed limestone surfacing in place:		
216,750 cu.yd. at $1.469.....		$318,437.59
Grading (Machine) 226,420 cu. yd. at $.179.....		40,582.95
		$359,020.54
Participation of funds:		
Federal labor.....	$152,154.03	
Federal other-than-labor	76,318.62	
Rock County.....	130,547.89	
Total		$359,020.54

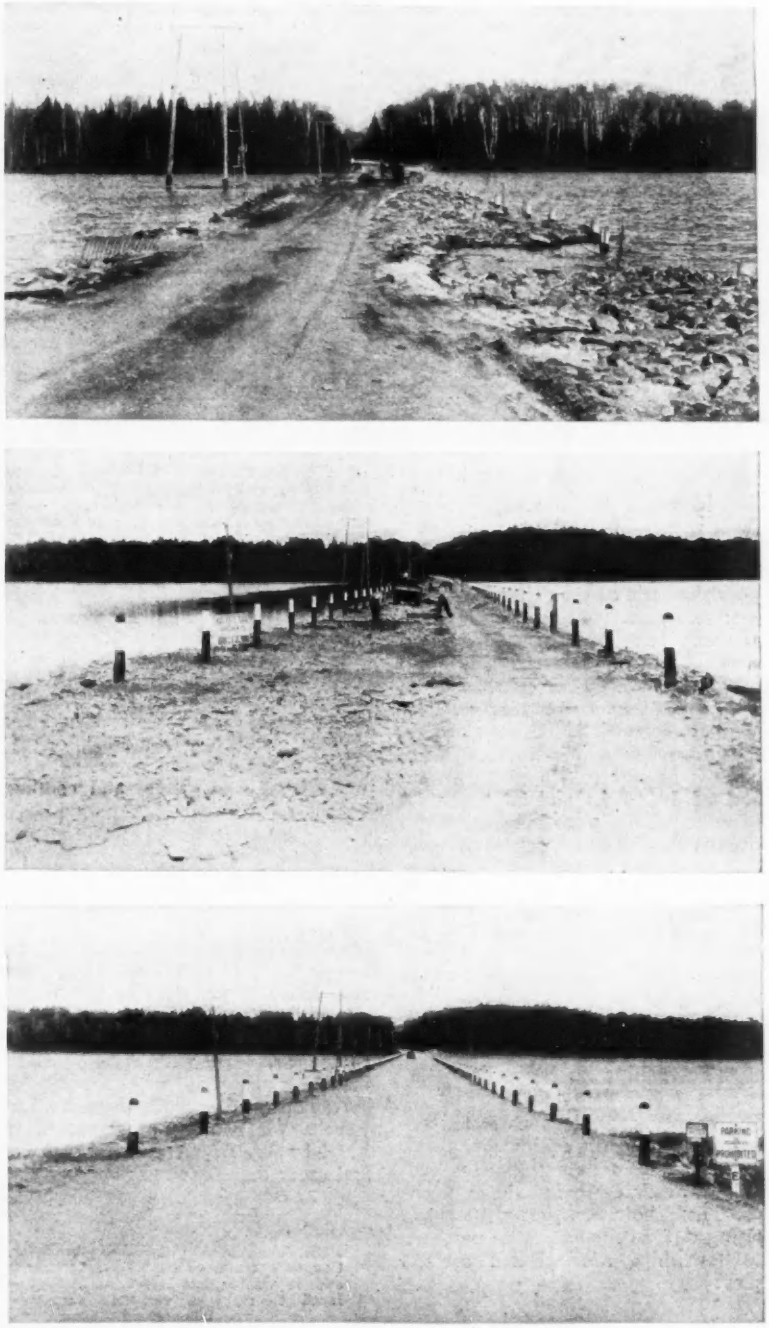


FIG. 3—REPRESENTATIVE TYPES of road work are indicated in these views of 5 mi. of road in Lac du Flambeau Indian Reservation; clearing, machine grading and hand trimming and sloping.

A six-mile section on a countrywide project sponsored by Lincoln County is representative of the work done on county trunk roads. This road connects with a county road in Langlade County to the north and serves the most thickly populated farming communities in both counties. In the town of Schley 200 farmers use this highway. This particular 6-mile stretch was perhaps the most poorly maintained part of the road. It originally had an 18-ft. top but the ditches had been allowed to fill in and were covered with vegetation. Culverts were completley buried, the gravel surface was worn away and the road was practically impassable from two to four months every year.

Preliminary work started the last week in June 1936, with a crew of 18 men. Right-of-way infringements were corrected, fences which had encroached on the shoulders were set back to their correct positions, the top was widened to 24 ft. and new ditches 1½ ft. deep were provided. All old buried culverts of 12 and 15 in. were replaced with 18 and 24 in. pipe. Six 2-ft. concrete culverts were blasted and replaced with new 30-in. pipe, 32-ft. long. One concrete and rubble stone bridge with a 14-ft. span and 14-ft. roadway was replaced by a steel arch bridge with a 14-ft. span and 30-ft. roadway. About 1,000 ft. of off-take ditches were dug.

An average crew of 18 men was maintained from June to September and then with the advent of drought

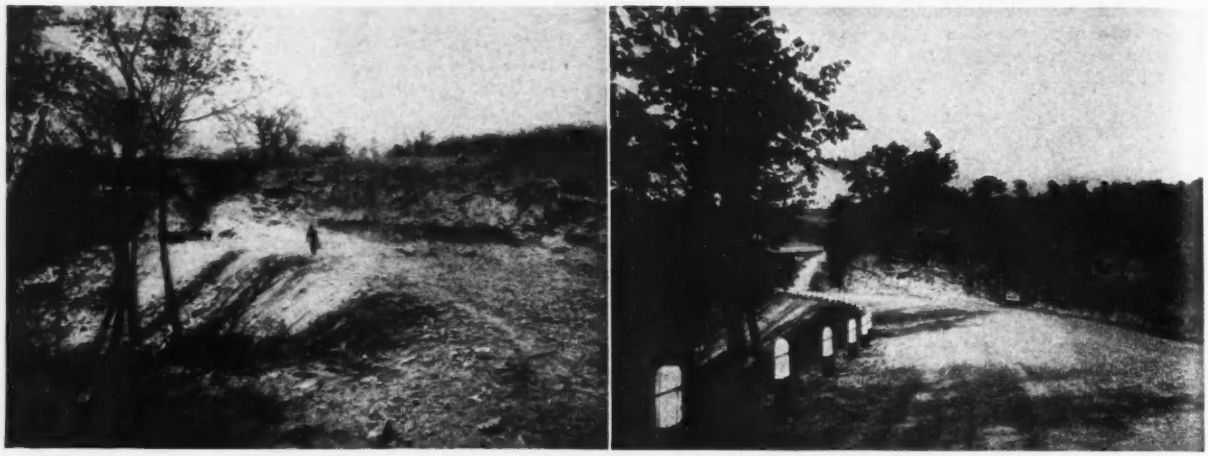


FIG. 4—A ROAD in Juneau County made over by widening and resurfacing; bold transformations like this were wrought in hundreds of places on the 5,000 mi. of backcountry roads.

relief increased to 70 men, at which level it was maintained until completion of the work on November 20.

Lincoln County furnished besides supervision, use of the following equipment: two tractors, one 2-ton tractor, two trucks, one gravel-crushing plant, and the following materials: 1,000 lb. of dynamite, six 30 in. culverts 32 ft. long, three 24 in. culverts 32 ft. long, two 18 in. culverts 32 ft. long, and the bridge previously mentioned. WPA furnished in addition to all labor, the rental of 14 trucks and 20 teams. A breakdown of costs covering the major items is given below:

Removing old bridge and building new	$2,156.50
23,100 cu.yd. earth excavation at $.508	11,685.00
6,300 cu.yd. of gravel (crushed and place) at $.938	5,910.40
Total	$19,751.90
Participation of funds:	
Federal	$14,109.00
Lincoln county	5,643.00

Townships no laggards

The county operations as stated enjoyed privileges of equipment, funds and engineering administration exceeding those available to individual townships. These, however, were not laggard in rising to the demands. Two northern state townships are selected as examples:

The town of Kelly, Bayfield County, has a population of 515 and a town road system of 42 miles all in heavy clay soil, with bad road conditions occurring every spring and fall. Work opened September 19, 1935, on 15.25 miles of the most important of the township's road system and continued, except for a suspension period of one month due to bad road conditions, until completion on November 20, 1936. Severe weather during January and February seriously hampered the work. The township rented a county-owned tractor and graded to shape the road bed to standard specifications for township roads as proposed by the Wisconsin highway commission. Labor and teams hired by WPA supplemented this equipment. Digging offtake ditches, installing culverts and loading and spreading gravel were done by hand. Trucks for hauling gravel were furnished by WPA. A summary of costs and other data follows:

15.25 miles of grading at $156	$2,379.00
Drainage (culverts in place)	876.00
8,540 cu.yd. gravel surfacing at $.928	7,926.00
Total cost	$11,181.00
Participation of funds:	
Federal	$8,587.00
Town of Kelly	2,594.00
Cost per mile	$733.18
Average number of men employed	14

The town of Washington, Vilas County, in the heart of Wisconsin's famous vacation-land furnished another example of a typical township-sponsored project. In this section of the county, as in sections of many other northern counties, many of the existing secondary roads originate from old logging trails and many of these have been only slightly improved. Stretches of road too narrow for two-way traffic, with steep banks obstructing vision around dangerous curves and narrow obsolete bridges characterize these trails. To improve 5½ miles of this type of road Washington township engaged an engineer to make a complete survey and plan, and obtained approval of a WPA project.

Work started September 16, 1935 with the federal government furnishing labor, teams, 2,000 lb. of dynamite, 850 ft. of galvanized sheet metal culverts and other minor items, while the township furnished a tractor, 10 ft. grader, fresno and dump truck. Up to October

FIG. 5—KANGAROO LAKE in Door County was crossed by a "country" road and it was widened, fenced and surfaced to make a veritable vacation-land boulevard.

15 about 4½ mi. of new grade had been completed and surfaced. The remaining mile of grading was scheduled for completion later in the fall, with the graveling to be carried on during the winter months. An average of 12 men were employed on this project. The project costs are as follows:

Earth excavation, 23,500 cu.yd. at $.543	$12,762.65
Corr. G.I. culvert pipe in place, 850 lin.ft. at $2.10	935.50
Clearing and grubbing, 9 acres at $72	648.00
Gravel surfacing, 1 mile at $765	765.00
Total	$15,111.15

Participation of Funds:	Federal	Township	Total
Labor	$9,069.83	$333.94	$9,403.77
Other-than-labor	2,189.09	3,518.29	5,707.38
Total	$11,258.92	$3,852.23	$15,111.15

Summed up

From an employment standpoint, Wisconsin's farm-to-market road program has been highly satisfactory. For the past fifteen months, it has furnished employment to the bulk of the rural relief load. Likewise, judging from the reaction of township and county officials and the public in general, the tangible improvements accomplished have been highly satisfactory. In fact the gist of the complaints usually received by WPA from these sources, is that the program is not extensive enough—that too many roads in urgent need of improvement are omitted. So far about ten per cent of the state's total mileage of secondary roads have been improved in some degree, a far greater accomplishment than was anticipated at the start of the program. Considering that the program was, of necessity, hurriedly and inadequately planned, this is a gratifying achievement. Much credit for this success must be given the various county highway departments who cooperated willingly and effectively.

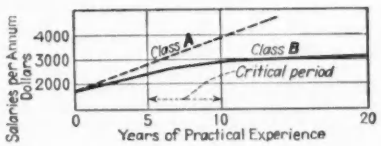
Letters to the Editor

Employment Opportunities In Engineering

Sir—A great deal is being said about the alleged scarcity of able and well-trained engineers. My observations lead me to state that, on the contrary, there are many experienced engineers walking the streets today, seeking that will o' the wisp—a job at a fair and equitable salary—bothering their friends and haunting the personnel departments of various companies.

I have diagnosed the situation in the field of engineering as follows: In most engineering organizations there are one or two Class A men around which the organization is built, and a number of subordinates that fall into a Class B category. Upon cessation of volume of work, the Class B men (receiving $2,500-3,000 per annum) are dismissed until such time as their original, or some other concern, have further need of their services. They may be just as able and just as competent as a Class A man, but unless forfuitous circumstances arise they always remain in the subordinate group; unfortunately, these men usually awaken too late to do anything about it. For that reason, the engineer who has become aware of the fact that he is in class B, should make every effort to find a new position which will afford him the opportunity of developing his talents to the full. This is the major problem confronting the average engineer between 30 and 40 years of age. The diagram illustrates the point I wish to make.

My advice to the young engineer may be summed up as follows: (1) Do not think, because you happen to have "taken" engineering, you are chained to it for life; and, (2) if within the first five or six years out of college you suspect that you are going to drop into Class B, take a look at the mercantile and industrial world and make up your mind to quit and develop your talents along other lines. The writer is a municipal engineer, registered as a professional engineer in two states, and speaks with a background of 14 years experience.



Salary variations with length of service in the two major classes of engineers.

WILLIAM STACK.

Park Ridge, Ill.
March 12, 1937.

Depth of Beams and Trusses

Sir—The young structural engineer and architect, in making a preliminary design, is often puzzled about what to anticipate for the depth of beams and trusses. Some beams may be designed completely, including their own weight, in one continuous operation. Others have to be designed by trial and error. In each case, the ratio of width to depth may be arbitrarily established preferably near the end of the computations. The best ratio of width to depth for isolated beams is the one which will give the cheapest design. For such cases, the economic ratio may be easily established; but when the depth of the beams is intimately related to the cost of the building exterior, the relationship is involved and a cheaper design may result if the beams are made shallow. Similar reasoning holds for the truss designs. What approximate depth, then, should one anticipate for the design at hand?

I have observed, in the average design, that for timber, steel, or reinforced concrete beams, and trusses in general, the ratio of depth in inches to the span in feet bears approximately the following relation:

Type of member	*Ratio*
1. Long girders (above 30′ span)	1.0
2. Short girders (below 30′ span)	1.25
3. Beams	1.0
4. Slabs	0.5
5. Flat trusses	1.0

S. SERGEV,

Seattle, Wash.
March 15, 1937

Department of Civil Engineering
University of Washington

Beam Deflections

Sir—My attention has been called to the letter in the Dec. 31, 1936 issue p. 939 by Robins Fleming in which he refers to a method published by the writer for evaluating integrals for deflections. It would seem that Mr. Fleming and Prof. Boyd, to whose book he refers, believe that I am the author of this useful theorem. Such is not the case for the theorem has been known in Central Europe for many years.

J. D. GEDO

New York, N. Y.
April 1, 1937

The Future of Grand Coulee

Sir—It was a pleasure to receive your letter of March 26 and to note your keen interest in the Grand Coulee Project. The progress in developing the program of going ahead with the irrigation works, which involves, of course, the completion of the Grand Coulee high dam, is described in our third report. The President has announced that he is in favor of completing the dam, provided Congress can satisfy itself that possible speculation in Columbia Basin lands can be controlled. So far, our commission has prevented any appreciable speculation in these lands, as you know, the government is able to prevent speculation at the time that water is to be delivered.

The hearings before the House subcommittee on appropriations on Grand Coulee will begin about April 5. We hope to obtain funds to continue construction at Grand Coulee after the foundations are finished in December, 1937.

JAMES O'SULLIVAN,
Secretary.
Columbia Basin Commission

Spokane, Wash., March 30, 1937

ENGINEERING NEWS-RECORD

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Editorial offices at 330 West 42nd Street, New York

April 8, 1937

A Nest-Egg

THE PROPOSED ship canal across Florida has at last received the approval of the Chief of Engineers, although not very hearty approval. General Markham recommends it as "worthy of favorable consideration." We hope that Congress will consider it but will come to the conclusion that the canal scheme can be used as a fine nest-egg for the collection of projects that the National Resources Committee would like to hold in readiness for the next depression. All our national planners have said much about the need for looking into the future for large national undertakings so that when another depression comes we will have projects all planned, ready to be started on short notice; but unfortunately most of the projects so far proposed are work that should not be put off indefinitely. However, no one seems to need the Florida canal badly, except possibly the owners of pleasure craft in Florida waters. The unemployment that it was started to reduce appears to be past, and Florida is reported to be booming again. Such being the case, the canal project should be laid aside now. At some future time we may know better what it will cost and whether it will pay.

Tin Cup Brigade

WHEN THE DEPRESSION was at the bottom the credit of municipalities disappeared like that of other enterprises. Government credit was therefore made available to municipalities, at first through the Reconstruction Finance Corporation, later through the Public Works Administration with its 30 per cent and 45 per cent grants. Still later came the Works Progress Administration, which on the pretext of unemployment relief built works for cities free of charge, incidentally creating new unemployment by taking away the occupation of regular craftsmen and contractors. Easy is the descent into hell but difficult is the ascent therefrom! How dependent the recipients of largess soon become is shown by the tin-cup begging attitude of the Conference of Mayors. If PWA grants are limited to the amount of relief wages paid, cities just cannot participate in the program, complains Paul V. Betters, spokesman of the Conference. Unquestionably, so long as PWA provides free money, city officials will form mendicant queues at Washington when they should stay at home and rebuild their cities. The administration would do the country a good turn indeed by discontinuing all semblance of giving away money for local projects.

Where Is the Unemployment?

ACCORDING TO THE PRESIDENT, the heavy industries have advanced too fast and the consumption goods industries have lagged; on this premise he announces the purpose to curtail construction and stimulate consumption. It happens that authoritative data in the President's own offices disprove his statements. Figures and charts in his Labor Department show that the consumption industries are above predepression level in both number of workers and total payrolls, while the heavy industries, and construction in particular, trail along far below normal. On the showing of these facts it is clear that the major source of unemployment is in the heavy industries, and that it is these industries that need every opportunity to continue their upward march to normal volume in order that the wasteful and degrading relief system may be ended. Just what purpose would be served by further "encouraging expenditure on consumer goods" is somewhat mysterious, in view of the fact that the consumption goods industries are working to capacity. The simple fact is that discontinuance of PWA grants and rigid restriction of relief-work activities to fields outside the normal requirements of cities and states would do most to return construction to normal, would reduce the list of unemployed and would enlarge purchasing power.

Same Old Story

LAST JUNE THE COLLAPSE OF an apartment house under construction in the Bronx, New York City, killed 18 workmen. Last week the architect, the builder-owner, the masonry contractor and two city building inspectors were convicted of second-degree manslaughter. The time between these two dates has been spent in spreading on the record the familiar story of shoddy speculative building, of disregard of public safety and of entire lack of professional responsibility. "Defective design, defective workmanship and the use of improper materials" is the characterization applied by a grand jury report. That sums up the whole story. And, with the technical and building skill that is available in this country and unused, it furnishes a shameful commentary on municipal building code management. Time and again the engineering and architectural professions have urged that all building be planned and supervised by licensed architects or structural engineers. They have gone farther and recommended that affidavits stating that the plans have been followed and a safe structure has been built be filed upon completion of the job. Qualification or licensing of contractors has also been suggested, and in spite of the disadvantages of such practice to reputable builders they must accept it in their own as well as the public's interest. The means to safe building are so readily available that city authorities who do not adopt them are guilty of criminal negligence.

Get the Evidence

SMOOTH CONTRACTUAL RELATIONS in construction are perhaps oftener disturbed by claims for extras and changes in plans than by any other disputes. The article in this issue on rights and procedures in claiming extras has therefore specific value to the contractor. But it claims notice also because it does not try to make the contractor a lawyer and a judge in his own right, as most published briefs of law and of judicial decisions on construction contracts tend to do. The contractor cannot and should not be made an interpreter of the law. He can and should be told how to collect and record evidence that the courts will respect—and this he seldom knows how to do or will take the trouble to do. Even the simple precaution of obtaining a written order for extra work is commonly neglected, and verification of the authority behind the order is still more rare. In pointing out clearly the importance of collecting and record-

ing evidence in claims for extra work and changes of plan, the present article carries a fundamental lesson.

New Pioneering

CURRENT ROAD-TRANSPORT REQUIREMENTS call for two kinds of pioneering: one, to take transport where it could not go before, the other to take more travel over old transport routes. Examples of both objectives are presented by the road-building in Wisconsin and in Missouri described in this issue. The work in Wisconsin is the pioneering of the colonist, opening up new traffic-producing regions. It is the simpler and better known task, for little remains to be learned about the engineering work of developing the back-country road and the woods trail. In contrast, rehabilitation of outmoded main travel routes is a new problem. Here the road-builder must turn to intricate analysis of volume, kind, speed and safety of transport and appraise their bearing on route alignment, on profile, and on roadway dimensions and surfaces. Since few of the facts involved can be measured precisely, research and experimentation are necessary. Up to now, however, highway research has been occupied largely with the technology of construction and has given little attention to travel speed, traffic segregation, accident causation and transport economics. These latter subjects indicate the path to be followed by highway engineers in exploring the problem of enlarging and rehabilitating the obsolete main road.

Rail Research Expanded

NOTABLE among the research that has been carried forward during recent years is that relating to railroad rails. It is a remarkable example of cooperative research to solve a common problem, in which competing railroads and steel companies joined their efforts to end the public risk involved in the sudden failure of a steel rail in track. But in addition the results obtained and their effect on rail manufacturing processes entitle the undertaking to high regard. While the ultimate cause of transverse fissures, the principal source of rail failure, has not been finally determined, yet methods of preventing or greatly reducing their formation have been discovered and have been applied to rail manufacture. All the principal rail mills now are resorting to controlled cooling of rails, a process that has been found to be helpful in reducing transverse fissures, and a few weeks ago the Carnegie-Illinois mill put into operation a plant for more complete heat treatment of rails.

But the work has not stopped here. As reported at the recent meeting of the American Railway Engineering Association (*ENR*, April 1, p. 486), the work that Prof. H. F. Moore has been directing at the University of Illinois is to be carried forward intensively for another two years, in confident expectation that solutions will be found for the still unanswered questions. In the meantime the equally notable work of the track stress committee is to be carried forward, supplemented by studies of welded joints and long welded rails and aided by new test devices that have been developed in recent years. These studies already have more than justified their cost through the improvements in locomotive design that they have caused and the consequent reduction in destructive forces acting on track that the improvements have brought.

From the record of what has been accomplished in the past few years it is apparent that, though the dark days of the depression years compelled the railroad companies to make drastic curtailments in their operating expenses, the companies never permitted the curtailment to put a complete stop to their research program. Now that conditions are improving the program is being enlarged considerably. As an essential part of the modernization of transportation methods and equipment, this railroad research is a contribution to public service as well as to engineering progress.

No Place for Politics

FOR SOME YEARS an unusually difficult combination of engineering and diplomacy has been going on along the Mexican border with great success. The adjustment of boundary and water problems along the Rio Grande has been carried on by joint Mexican and American commissions on a basis of precise determination of the engineering facts involved, followed by agreement on remedial steps in accordance with the showing of these facts. Just now the survival of this work is being threatened by a movement to put a politician in the place of the engineer commissioner who represents the United States.

To illustrate the unusual border work: Where the action of the river cut off one of its bends and transferred a piece of land from the southern side to the northern side of the river, Mexican sovereignty survived, and thus part of Mexico came to lie north of the Rio Grande. By similar action, of course, numerous pieces of American territory found themselves located south of the river. For many years these "bancos", as they are called, had been a source of trouble between the two countries, but when the engineering commissions took up the problem their extinction became possible. In the just completed rectification of the river between El Paso and Fort Quitman an interchange of ownership in the *bancos* was found possible, by the ingenious device of so laying out the river's rectified course as to make the amount of territory transferred from Mexico to the United States precisely equal to that transferred in the other direction. Solution of the problem would have been impossible had it not been inspired and guided by engineering knowledge.

Every other boundary problem along the river is similarly dependent on engineering analysis. The works at Nogales and at El Paso, as well as the flood-protection operations near the mouth of the river, are of this kind; in no case could effective cooperation of the two countries have been attained without engineering study and conclusions. Still more important is engineering approach to the as yet unsolved problem of determining equitably the rights of the two countries to the use of the Rio Grande's waters.

The proposal to displace the present American commissioner, the able and efficient Lawrence M. Lawson, in favor of a politician has no other virtue than to provide patronage. It would destroy much that has been accomplished to date and would render impossible an adjustment of the serious water-rights situation that is developing along the border. The Mexican boundary work has brilliantly demonstrated what can be accomplished through a proper union of engineering and diplomacy. Its continuance on the same basis is clearly in the national interest.

CURRENT NEWS

Army Study Approves Florida Canal

Chief of Engineers recommends Florida canal be built in six years at cost of $200,000,000

Reversing the conclusion of the Board of Engineers for Rivers and Harbors and concurring with that of a special board of review, Major-General Markham, Chief of Engineers, on April 5, recommended to Congress that the Florida ship canal be built at an estimated cost to the federal government of $197,921,000 in addition to local contributions aggregating about $3,000,000.

The Chief of Engineers recommends construction of a canal following the St. Johns-Oklawaha-Withlacochee Rivers, having a minimum depth of 33 ft. increasing to 34 ft. in the outer section of the Gulf approach channel; with a minimum bottom width of 400 ft. increasing to 500, 730, and 1,000 ft. in the Gulf approach channel; with protective jetties extending 17 mi. into the Gulf on the south side and 4½ mi. on the north; subject to the condition that local interests furnish all necessary lands and rights of way and accept the obligation of maintaining and operating the original bridges and constructing any further highway bridges that may be needed. Construction should be planned for completion in six years.

General Markham's report struck a balance between the findings of the special revisory board of review (*ENR*, Dec. 3, 1936, p. 796) and of the hitherto unrevealed report of the Board of Engineers for Rivers and Harbors. His outstanding conclusions are as follows:

There is little disagreement as to the amount of traffic that will use the waterway; the differences of opinion occur as to whether the resulting benefits will justify the cost. Factors affected by honest differences of opinion include: Cost of excavation in soft rock, utilizing hydraulic dredges on an unprecedented scale. Speed which vessels can maintain in the canal, depending upon its width and depth. Annual cost of maintenance.

Borings along the line of the canal indicate that the cost figures of the revisory board are ample, those of the rivers and harbors board too conservative.

The success of the canal depends upon safe and expeditious transit. The 250-ft. minimum width recommended by the revisory board should be increased to the 400-ft. minimum recommended by the rivers and harbors board. The 35-ft. minimum depth recommended by the former is satisfactory, and it is not necessary to increase this to 35 ft., recommended by the latter.

Interest rates during the construction period are set at 3 per cent increasing to 3⅛ per cent thereafter. (Previous estimates assumed 4 per cent.) There is no reason for an amortization charge, since the project life will be unlimited.

"A sea-level canal will not, to any consequential or vitiative degree, influence the ground water levels of the state, or result in serious intrusion of salt water." The revisory board held that any effect upon ground water would be limited to the vicinity of the canal; the rivers and harbors board found that plans should be held open to shift to a lock canal if, during construction, such modification should appear to be warranted, and that the federal government should anticipate claims for damages from this cause.

The foregoing considerations indicate that the canal can be built in a 6-year period (at present prices for materials and labor) at a cost to the United States of $197,921,000 and of $3,000,000 to local interests, with annual maintenance and operation at $1,090,000. Annual benefits to shipping will be $8,741,000, as compared with annual charges of $8,641,000 to the United States and $264,000 to local interests. The revisory board cost estimate was $162,985,000, including the $5,400,000 already expended but not including a local contribution of $5,500,000. The rivers and harbors board estimate was $265,282,000.

Other considerations to be given weight include: The probability that there will be a sustained and substantial increase in the volume of Gulf shipping. The dual purpose of public works in providing employment for those who would otherwise require relief as well as providing of useful facilities. "If the amount to be expended for labor in whole, or in substantial part, is deducted from the capital investment, the canal will show a handsome profit in benefits to shipping."

—◇—

Georgia TVA Decision Upheld By U. S. Supreme Court

The U. S. Supreme Court on April 6 denied an application of the Georgia Power Company to reverse the order of the United States District Court in Georgia forbidding the company to enforce, in the state of Georgia, the Gore injunction, which was granted by the U. S. District Court in Tennessee, forbidding further expansion of TVA power activities.

The action of the Georgia District Court was upheld March 17 by the U. S. District Court of Appeals in New Orleans. The power company then appealed to Justice Cardoza, and the appeal was referred by him to the full bench for action.

Judge Underwood, of the Georgia District Court, charged utility companies with shopping around for a friendly court and ruled that the Tennessee injunction was not effective within his jurisdiction in view of a previous decision of the Georgia court against the utility.

On April 1, TVA filed an action in Birmingham before the U. S. District Court in Alabama, seeking to have the Gore injunction declared ineffective in Alabama on the basis of a previous decision upholding the right of TVA to sell power in that state.

Two States Act on Public Housing

Arkansas passes and New York proposes legislation to facilitate local action on low cost housing

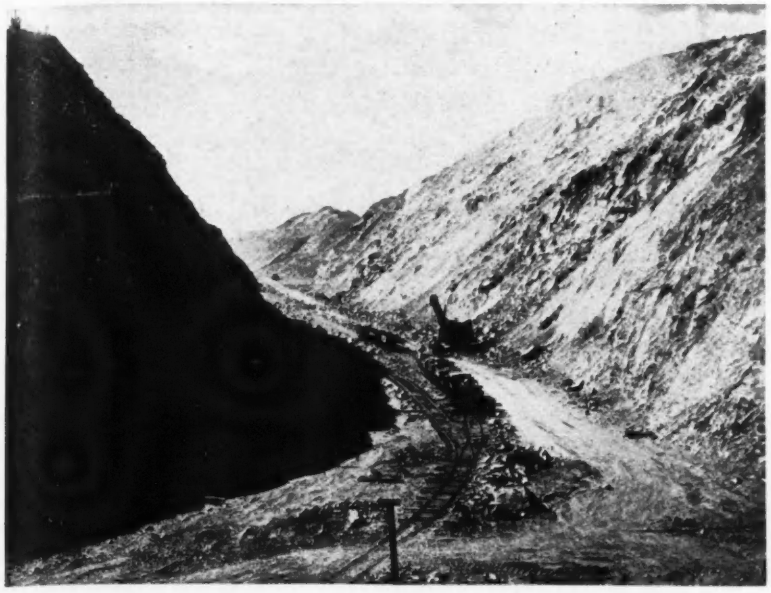
Governor Bailey of Arkansas has signed a bill enacted at the recent session of the legislature authorizing municipalities to create a housing authority with power to undertake slum clearance or low-rent housing projects and another bill authorizing and regulating the issuance of bonds to refinance or improve revenue-producing public works projects in incorporated towns and cities of the first and second class. The slum clearance bill provides that dwelling accommodations shall be available only to tenants whose aggregate income does not exceed five times the rental of the quarters to be furnished. The revenue bond bill authorizes municipalities to refund or issue bonds to finance public works, interest and principal on such bonds being payable from the revenues of the projects and not backed by the taxation power of the municipalities.

Meanwhile, in New York State, which already has a law providing for local housing authorities, two constitutional amendments were introduced into the legislature, following the recommendations in a message from Governor Lehman. One of these would empower the state to issue bonds to set up a revolving fund, from which to make housing loans to local housing authorities, and the other one would modify municipal debt limitations to permit bonds for housing purposes.

The first amendment provides for the setting up of a revolving fund from which loans may be made to public corporations for the purpose of eradicating slums or providing low-cost housing facilities. The state is given the power to borrow money for setting up such a fund without the necessity of a popular referendum unless the amount of the debt contracted exceeds $100,000,000.

The second amendment authorizes counties, cities, towns, and villages to give aid to public corporations for slum clearance and low-cost housing, and permits any city to become indebted for housing purposes outside of its regular debt limit. Such debts may be contracted by the city without a referendum up to the amount of 2 per cent of the assessed valuation of the city; debts may be incurred to a greater amount than this if permission is granted by public referendum. It is provided that "any indebtedness . . . incurred by the city . . . for slum clearance and for providing housing facilities for persons of low income . . . shall not be computed in ascertaining the power of such city to become otherwise indebted."

A constitutional amendment in New York state must be acted upon by two different sessions of the legislature and submitted to the people at a general election for approval. These amendments could be placed before the people in 1939.



CANAL THROUGH THE MOUNTAINS

A DEEP CUT is shown on the route of the All-American Canal. Although for most of its length the big irrigation ditch, being dug by the Bureau of Reclamation along the Mexican border in Southern California, is in the desert, it crosses a range of rocky buttes. The view shows the work in one of the deepest rock cuts, Pilot Butte, west of Yuma, Ariz.

Six Convicted of Manslaughter In Bronx Apartment Collapse

A Bronx County jury on March 31 returned a verdict of guilty of second degree manslaughter against six men in connection with the collapse last June of a six-story apartment house under construction in the Borough of the Bronx, New York City, in which 18 men were killed. The verdict carries a maximum sentence of 15 years in prison and $1,000 fine. The men convicted are Louis Steinberg, builder-owner; Max Steinberg, his son; Harry B. Rutkins, architect; Vincent Valentine, masonry contractor; Michael C. E. Thiede, plan examiner for the Bronx Bureau of Buildings; and Albert F. Heine, masonry inspector for the Bureau.

The prosecution had brought evidence during the trial that the building had been erected too hastily and with inferior materials. It was stated that an appeal would be taken from the verdict.

On April 3, after the conclusion of the trial, recommendations for amendment to the building laws, made by the grand jury of the Bronx last June at the time they were investigating the collapse, were released; they had been held secret pending disposition of the criminal trial of those concerned in the building.

Attributing collapse of the Bronx apartment building "to defective design, to defective workmanship, and to the use of improper materials," the grand jurors recommended adoption of a regulation that plans submitted to the building department for approval should not only be prepared and designed under the supervision of a registered architect but also be accompanied by an affidavit from a licensed professional engineer stating that he has examined the plans and approved them.

The jurors further recommended that the qualifications of plan examiners for the building department be raised to require that an applicant for the position of plan examiner be a registered architect or licensed professional engineer with at least two years practical experience. If the applicant is not a registered architect or engineer, the jury recommended, at least five years of practical experience should be required.

Manitoba Bridge Span Moves To New Brunswick

Bids have been called by the Canadian National Railways for construction of its new bridge over the St. John River at Fredericton, N. B., replacing that washed out by the 1936 flood.

The old Fredericton bridge, a 9-span structure valued at $1,500,000, was completely demolished last spring. The wreckage has since been removed from the river by contract. It was located on a comparatively unimportant line which, however, forms a vital link between central New Brunswick and the northern coast of the province so that local demands for the replacement of the bridge have been strong.

An interesting feature of this job lies in the fact that the new bridge, which is to include seven fixed spans and a swing span, will obtain its swing span from an old bridge which crosses the Red River at Winnipeg, Man. The Winnipeg bridge consists of six through-truss spans and a swing span and is not now in use since all C. N. R. traffic at Winnipeg is routed over a more recently built bridge a short distance downstream.

Flood Plan Drafted For New England

Sub-committee completes draft of interstate compact for flood control in Connecticut Valley

A four-state compact between Connecticut, Massachusetts, Vermont and New Hampshire for flood control on the Connecticut river has been drawn up by a subcommittee named by the several governors at their conference in Hartford recently and now awaits action by the legislatures of the states involved. The conference provides for the initial construction of eight reservoirs at an estimated cost of about $12,700,000. The Federal Government would provide about $10,000,000 of this, under the terms of the omnibus flood control act of last year, and $2,700,000 would be provided by the states. Fifty per cent of the state's contribution would come from Massachusetts, 40 per cent from Connecticut, and Vermont and New Hampshire would each provide 5 per cent under the terms of the agreement.

The compact sets up a Connecticut River valley flood control committee with three salaried members from each state, provides for the setting up of an organization, and gives the board wide powers with respect to operation.

The eight initial reservoirs are to be built from the following list of eleven proposed storage basins:

Victory, Vt., Moose River
Union Village, Vt., Ompompanoosuc River
North Hartland, Vt., Ottauquechee River
Croton, Vt., Wells River
Bethlehem Junction, N. H., Ammonoosuc River
Stocker Farms, Gransham, N. H.
Fury Mountain, N. H., Ashuelot River
Knightsville, Mass., Westfield River
Tulley, Mass., Tulley Brook
Priest Pond, Mass., Twin Brook
Lower Naukeag, Mass., Millers River

The proposed contract provides that each state shall acquire title to the land, easements and rights of way involved in the construction of the proposed reservoir, by purchase or right of eminent domain, at the request of the commission. Highway relocations and relocations of transportation lines, power lines and other public utility factors are to be procured by each state at the expense of and upon the request of the commission. The land and other properties acquired by the states are to be leased for 999 years to the commission solely for flood control, each state reserving to itself all benefits of water conservation, power storage, or power development that may be inherent in each reservoir site within its borders; the right of development of such benefits would be subject to the requirement set up by the federal government that the state benefited must pay the extra construction cost involved in the development of other values than flood control.

The commission which is being set up under the proposed contract would determine, with the approval of the Secretary of War, the order of the work, except that one reservoir must be begun in Massachusetts and one each in Vermont and New Hampshire before any other construction takes place. The proposed eight-reservoir plan is part of a long-range program which would ultimately involve the construction of twenty reservoirs at a cost to the federal government of $44,261,000 and to the states of $10,575,000. The compact, to be-

(*Continued on page* 536)

Blueprint and Pipe Makers Cited

Federal Trade Commission charges unfair practices by manufacturers of blueprint paper and cast iron pipe

The Federal Trade Commission has issued a complaint charging that 35 companies producing 90 per cent of the output of cast iron soil pipe in the United States have, through the use of the Birmingham Plus basing point price system, lessened competition within their industry and discriminated against certain buyers of their products. The complaint charges violation of both the Federal Trade Commission Act and the Robinson-Patman anti-price discrimination act.

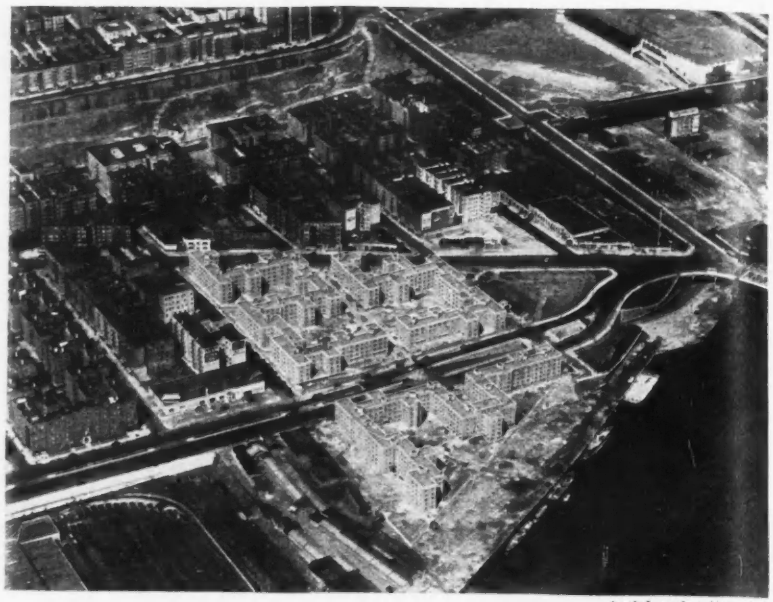
Charges of violation of the Federal Trade Commission Act have also been issued against eleven companies and their trade association which are said to dominate the production and distribution of blueprint paper and other drafting room papers and cloth. The complaint alleges that the trade association, Scientific Apparatus Makers of America, Chicago, and its members combined to fix and maintain prices, control bidding, and commit other unfair trade practices.

The companies named in the complaint are: Charles Bruning Co., Inc., and Eugene Deitzen Co., of New York City; Keuffel & Esser Co., Hoboken; the Huey Co., the Frederick Post Co., Economy Blueprint Products, Inc., the C. F. Pease Co., and the United States Blueprint Paper Co., of Chicago; the Keystone Bluepaper Co., Charles W. Speidel & Co., and J. H. Weil & Co., of Philadelphia.

Complaint against pipe company

In the other complaint the Federal Trade Commission charges that the Cast Iron Soil Pipe Association, of Birmingham, Ala., and its member companies have combined for more than ten years to lessen and restrain competition, and for that purpose have used the Birmingham Plus price system, under which cast iron soil pipe, wherever produced, is sold at delivered prices which are equivalent to the base price fixed at Birmingham plus the freight rate from Birmingham to the buyer's freight station, wherever located. It is charged that trade discounts are deducted from the delivered prices, which vary for buyers of different classes, but are uniform to buyers of the same class. The respondents are asserted to combine to adopt uniform terms of sale, uniform forms of contract, and a uniform system of classification of buyers and of preferential discounts to certain classes of buyers. It is charged that the respondents enforce their agreement by meetings, correspondence, and constraint upon members of the association who do not adhere to the agreement and upon non-members. These acts are stated by the commission to be violations of the Federal Trade Commission Act and of the Robinson-Patman Act.

The producers named in the complaint are: Alabama Pipe Company, Anniston, Ala.; Anniston Foundry Company, Anniston; Anniston Soil Pipe Company, Anniston; Buffalo Pipe & Foundary Corporation, Tonawanda, N. Y.; Central Foundry Company, New York City; Charlotte Pipe & Foundry Company, Charlotte, N. C.; Crown Pipe & Foundry Company, Jackson, Ohio; Drapery Hardware Company, Los Angeles; Eastern Foundry Company, Boyerton, Pa.; East Penn Foundry Company, Macungie, Pa.; Essex Foundry Company, Newark, N. J.; Fraters Valve & Fitting Company, Los Angeles; Goslin-Birmingham Manufacturing Company, Inc., Birmingham; The Hajoca Corporation, Philadelphia; Hedges-Walsh-Weidner Company, Chattanooga; Hercules Foundry, Inc., Los Angeles; Interstate Foundry Company, Anniston; Jakes Foundry Company, Nashville, Tenn.; Kilby Pipe Company, Anniston; Medina Foundry Company, Medina, N. Y.; Medina Iron & Brass Company, Medina, N. Y.; N. O. Nelson Manufacturing Company, St. Louis; Pacific States Cast Iron Pipe Company, Provo, Utah; Pacific States Cast Iron Fitting Company, Los Angeles; Rich Manufacturing Company, Ltd., Los Angeles; Rudisill Foundry Company, Anniston; Salem Brass & Iron Manufacturing Company, Bridgeton, N. J.; Sanitary Company of America, Linfield, Pa.; Sanitary Pipe Company, Alexander City, Ala.; Southern Pipe & Foundry Company, Inc., Knoxville, Tenn.; Southern Pipe & Foundry Company, Birmingham; Stringer Bros. Company, Inc., Chicago; Walker Machine & Foundry Corp., Roanoke, Va.; Walworth-Alabama Company, Attalla, Ala.; and Harry C. Weiskittel Company, Inc., Baltimore.



Aerial exploration photo

RENTALS SET FOR HARLEM RIVER HOUSES

AN AVERAGE rental of $7 per room per month for Harlem River Houses, $4,219,000 PWA housing project in New York City, has been announced by Administrator Ickes. An additional charge, covering gas and electricity for gas stoves and electrical refrigeration will be made at a flat rate averaging $1.42 per room per month.

The project, financed, built and owned by PWA, will be leased to the New York City Housing Authority in order to achieve decentralization and local control of housing.

The 574-unit project, which is intended for Negro families, will be completed some time this summer. Bounded on the East by the Harlem River, and on the West by Macombs Place, the site, between 151st St. and 153rd St. is divided into two parts by 7th Ave. Beyond the 157th St. viaduct which leads onto the Central Bridge, the Polo Grounds can be seen. The buildings, of concrete frame construction with brick curtain walls, are 5 stories high and cover about 35 per cent of the 8.5-acre site.

A. M. Brown is the chief architect, and the Cauldwell-Wingate Co is the contractor on the project.

Engineering Scholarships Given Sanitation Employees

All the employees of the New York City Department of Sanitation who are high school graduates have been invited to compete for a scholarship covering a course in sanitary engineering at New York University under the terms of a joint project of the New York City administration and New York University.

An examination will be conducted by the University, and a list of successful candidates will be submitted to the Mayor, who will designate five of them for the free four-year course in the University's college of engineering. The examination, to be held June 14, will be open to male employees of the department of sanitation who are graduates of high school or have attended college, except that persons who already have had engineering training will not be permitted to qualify without special permission. At the expiration of the application period 220 employees of the department had indicated their intention of taking the examination.

It is stipulated that any employee who accepts the scholarship must agree to remain in the department at least four years after completing the course. The department will continue to pay each student his full salary, and he will be required to put in his full day's work, but his hours will be adjusted not to interfere with his studies.

Explosives Expert Reports On New London Disaster

Secretary Wallace has forwarded to Governor Allred of Texas the preliminary report of Dr. David J. Price, explosion expert of the Bureau of Chemistry and Soils, on the investigation of the explosion in the school building at New London, Texas, March 18, which resulted in the death of 455 school pupils. Doctor Price was detailed by Secretary Wallace to cooperate in the investigation of the explosion at the personal request of Governor Allred.

In his report Doctor Price states that in his opinion the explosion was due to the ignition of an accumulation of combustible gases in an open area underneath the first floor of the building by a flash from electrical equipment in connection with the operation of a sanding machine located in the manual training shop, as stated in our news account (*ENR*, March 25, p. 459).

Price recommended the following precautionary measures for prevention of explosions in public buildings and institutions:

Required use of effective malodorants for detection of escaping combustible gas due to leaking equipment or other causes.

Application of gas indicators to detect presence of escaping combustible gases at percentages below the lower limit of explosibility and development of alarm systems and warning devices for school houses and public buildings.

Provision for supervision and inspection of installations of heating and lighting devices and equipment in public buildings.

Installation of all electrical equipment and appliances in accordance with requirements of National Electrical Code.

Provision for proper construction of buildings to prevent dead storage space underneath class recitation rooms and similar meeting rooms where dangerous gases can accumulate.

Provision for adequate ventilation of necessary spaces under all occupied sections of public buildings.

Provision for adequate ventilation at all times in school rooms using gas heating.

Secretary Wallace advised Governor Allred that Doctor Price is now preparing a detailed report covering the investigation of the explosion.

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Back Bay Subway Bill Passed at Boston

A bill providing for a subway under Huntington Avenue, Boston, from Copley Square to the Mechanics Building, at an estimated cost of $1,750,000, has been signed by Gov. Hurley of Massachusetts. The act directs the Boston Transit Department to build the tunnel. The work will result in the removal of all surface cars from Boylston Street and Copley Square and shorten the running time of lines between the Roxbury-Brookline area and the heart of Boston by about 5 minutes. The route passes under the tracks of the Boston & Albany Railroad. The act must be approved by the mayor and city council and by the Boston Elevated Railway to become effective, but this is anticipated. It is expected that Boston's share in the cost will be about $500,000 and that the Federal government may contribute $1,200,000.

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Pocono Water Supply Urged By Philadelphia Mayor

Mayor Wilson of Philadelphia, in a radio talk April 1, announced plans for a $75,000,000 water system to bring water to Philadelphia from the upper Lehigh Valley in the Pocono Mountain region. It was proposed that the system be constructed by the city by means of a special issue of 50-year bonds.

The plan, which the Mayor said "is the result of several exhaustive surveys that have been made since I took up the duties of the office of Mayor", would contemplate the sale of a large quantity of water to other cities and the generation of power, which would be sold to utility companies. The Mayor stated that revenue from these sources would meet the cost of the project.

To Test Power Sale By San Francisco

Secretary Ikes moves for court test of legality of sale of Hetch-Hetchy power by San Francisco

As a result of the failure on March 9 of San Francisco voters to approve a $50,000,000 bond issue to provide distribution facilities for Hetch-Hetchy power, Secretary of the Interior Ickes on April 2 formally requested the Department of Justice to initiate court action against this city for alleged violation of the Raker act. This action was taken with the approval of the San Francisco Board of Supervisors, who feel that the present sale of power to the Pacific Gas & Electric Company is not a violation of the act and desire a court test.

The Raker act, passed in 1913, granted the city the right to construct its water supply and power projects on Federal land in Yosemite National Park and the Stanislaus National Forest under certain conditions, one of which provided "that the grantee is prohibited from ever selling or letting to any cooperation or individual, except a municipality or municipal water district or irrigation district, the right to sell or sublet the water or the electric energy sold or given to it, or him, by the said grantee."

In 1925, shortly after completion of the project, the city arranged for the transfer of power from the project to the Pacific Gas & Electric Co. under a so-called temporary agency agreement, and the power is still being disposed of by this arrangement. Secretary Ickes considers this arrangement to be a violation of the act and so notified the city. After a hearing and considerable negotiation, a plan for municipal distribution was devised by the city and met with the approval of the secretary, but the bond issue necessary to finance it was voted down March 9.

Immediately after the election, Secretary Ickes notified the city that it would have 15 days in which to cease violating the

(*Continued on page 536*)

Owens-Illinois Glass Company photo

GLASS BLOCK WALLS ENCLOSE COLUMBUS PRINTING PLANT

ONE of the most spectacular applications of glass blocks to a building enclosure has just been completed by the Capitol Square Corp., Columbus, Ohio. The building will be occupied by the American Education Press.

Three stories high and 148 x 188 ft. in plan, the building is of reinforced concrete flat-slab construction. Floors are cantilevered beyond the exterior columns, so that the runs of glass blocks will be uninterrupted. Spandrels are limestone and brick. The first two floors are devoted to the printing plant, and the offices are on the top floor.

Housing Laws Lag In Many States

Washington Correspondence

With adjournment imminent for many of the 45 state legislatures meeting in 1937, the Housing Division of the Public Works Administration has issued a warning that lack of complementary state legislation authorizing the formation of local housing authorities will undoubtedly bar many states from participating in the benefits of future federal efforts to promote low-cost housing.

Although federal plans, as embodied in the Wagner bill, are still subject to the action of Congress, it is accepted that the emergency era of direct construction by the federal government is over and that future operations will be decentralized into the hands of local or regional authorities which will be aided by federal subsidy. State legislation is necessary to authorize the formation of these public corporations, and it is desirable, in addition, to have legal authorization for the exemption of such bodies from taxation and to permit active cooperation between them and the governments of the cities, counties and regions in which they are authorized to operate.

Laws providing for the formation of housing authorities are now in effect in 27 states: Alabama, Arkansas, Colorado, Connecticut, Delaware, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Montana, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, West Virginia, Wisconsin, and Georgia. In a few instances the laws require amendment or extension to reach full efficiency.

States without adequate housing legislation, where the legislatures are not meeting or have already adjourned, are Arizona, New Mexico, South Dakota, Utah, Wyoming, and Washington. If the Wagner bill, or a substitute, passes Congress these states will be unable to conform to its requirements without calling a special session. Maine and New Hampshire, which have considered and defeated proposed housing measures, should also be included in the category of states definitely outside of a possible housing subsidy.

Bills relating to low-cost housing in one way or another are under consideration in California, Kansas, Minnesota, Missouri, New York, Oklahoma, Pennsylvania, Illinois, Iowa, Nebraska, Massachusetts, Michigan, and Vermont. Some of these amend, extend or clarify previous legislation.

New England Flood Plan

(*Continued from page* 533)

come effective, must be approved by the state legislatures and by Congress.

Recently an opposition movement has arisen among members of the public power bloc in Congress, opposing ratification of the agreement unless it provide that the federal government rather than the participating states shall own the dams and unless provision be made for federal hydroelectric power development.

WORK RESUMED AT GRAND COULEE

THE LAST COFFERDAM at Grand Coulee dam, where work has been resumed to uncover the last of the foundation rock. In the distance is the block of 1,850,000 cu. yd. of concrete already poured in the west section of the dam.

Two State Legislatures Pass Registration Bills

Nebraska and Texas have just passed bills providing for the registration of engineers.

The Texas law, which applies only to construction engineers, creates a state board of registration and requires the registration with it of all professional construction engineers in Texas. Graduates of four-year college courses with one year of actual practice would be licensed without examination. Non-graduate engineers would be examined and would be required to undergo an apprenticeship. During the first five years of the act, engineers with 12 years practice would also be exempted from examination.

The Nebraska bill requires the governor to appoint a five-member board, three engineers and two architects, and requires all engineers and architects in the state, with the exception of those engaged exclusively upon irrigation or rural electrification projects, to register with the board. The requirements for registration are based on those in the model law, requiring all persons registering in the future to take examinations and to show 8 years of experience in engineering or architecture, with college professional training counting as experience up to 4 years. Licenses may be revoked for unprofessional conduct. Municipalities and other governmental subdivisions are required to hire registered engineers on construction projects costing more than $10,000.

Test Hetch Hetchy Power Sale

(*Continued from page* 535)

act, after which the matter would be referred to the attorney general for action. City officials replied with the statement that they intended to take no action and requested that the matter be taken to the court, in order to determine whether or not the Raker act is being violated by the present arrangement.

Although the form of legal action to be taken is subject to the decision of the attorney general, the secretary's letter to him suggests an application for an injunction against the further transfer of power from the project to the pacific Gas & Electric Company.

Canada to Build Dam On Richilieu River

The Canadian House of Commons has approved the expenditure by the Federal Government of $500,000 for the construction of a regulating dam on the Richilieu River in the Province of Quebec, between St. John and Chambly. While the proposed dam is not connected directly with the proposed canalization of the Richilieu River, now under consideration by the International Joint Committee, it is stated that its construction would improve navigation between Chambly and St. John.

Minister of Public Works Cardin has explained that the purpose of the dam was to give effect to the order made by the International Joint Committee in 1907 when regulation of the Richilieu River was being discussed. It was then proposed to dredge the river between the International Border and St. John in order to improve the run-off down the river in time for the spring floods. Objection was raised to this procedure by the United States Government on the grounds that the dredging would also increase the run-off at all other times. It was therefore agreed that a regulating dam should be built which, in conjunction with dredging, would hold up the river flow at times of low water.

SOCIETY CALENDAR

AMERICAN SOCIETY OF CIVIL ENGINEERS, spring meeting, San Antonio, Texas, April 21–24.

NATIONAL RIVERS AND HARBORS CONGRESS, annual convention, Washington, D. C., April 26–27.

NATIONAL LIME ASSOCIATION, annual convention, Chicago, Ill., May 11-12.

BUILDING OFFICIALS OF AMERICA, annual convention, Cleveland, Ohio, week of May 31.

AMERICAN WATER WORKS ASSOCIATION, annual convention, Buffalo, N. Y., June 7-12.

AMERICAN WATER WORKS ASSOCIATION, CANADIAN SECTION, Montreal, Canada, April 14–16; MONTANA SECTION, Lewiston, Mont., April 19–23; FOUR STATE SECTION, Philadelphia, Pa., April 22–23; ILLINOIS SECTION, Springfield, Ill., April 29–30; PACIFIC NORTHWEST SECTION, Victoria, B. C., May 20–23.

ARKANSAS WATER WORKS CONFERENCE, annual conference, Fayetteville, Ark., April 12–14.

GREATER NEW YORK SAFETY COUNCIL, annual convention, New York City, April 13–15.

MICHIGAN ENGINEERING SOCIETY, annual meeting, Saginaw, Mich., April 15-17.

PENNSYLVANIA WATER WORKS OPERATORS ASSOCIATION, joint meeting with A.W.W.A., Four States Section, Philadelphia, Pa., April 22-23.

CALIFORNIA SEWAGE WORKS ASSOCIATION, spring conference, Stockton, Calif., April 23–24.

MARYLAND-DELAWARE WATER & SEWAGE ASSOCIATION, annual conference, Wilmington, Del., May 6–7.

NORTH CAROLINA INDUSTRIAL SAFETY CONFERENCE, Winston-Salem, N. C., May 20–21.

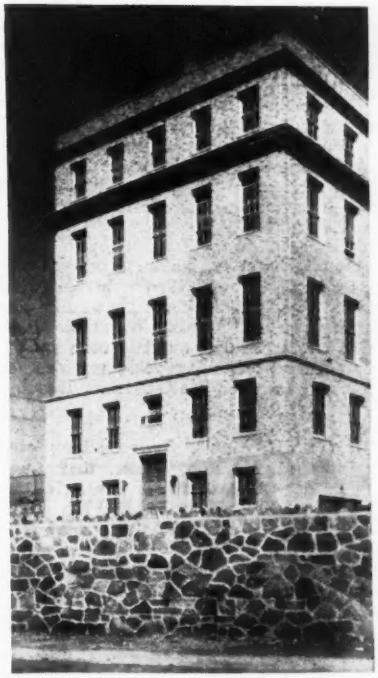
NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS, annual meeting, New York City, May 22.

The following officers have been elected by the OHIO SOCIETY OF PROFESSIONAL ENGINEERS: president, J. R. Burkey; vice presidents, Victor Smith, Harry C. Miller; treasurer, Edward C. Bellefontaine; secretary, John Laylin.

At the annual convention Feb. 25–26 of the MINNESOTA SURVEYORS AND ENGINEERS SOCIETY, H. E. Chard was elected president; C. J. Gladman, secretary-treasurer; and R. E. Odendahl, vice-president. C. L. Methven, retiring president, was elected representative on the Minnesota Federation of Architectural Engineering Societies.

Departing from the usual practice of holding an annual spring meeting, the fifth annual ILLINOIS MINERAL INDUSTRIES CONFERENCE will be held at Urbana, Ill., Oct. 8–9. All future meetings will probably be held in the fall. Announcement of the program will be made later this spring.

Arthur D. Weston, chief engineer and director of the Massachusetts Department of Health, was elected president of the BOSTON SOCIETY OF CIVIL ENGINEERS at its annual meeting March 17. Other officers elected were: vice-president, Gordon M. Fair; secretary, Everett N. Hutchins; treasurer, Charles R. Main; directors, Howard M. Turner and Carroll A. Farwell. The Desmond Fitzgerald medal was awarded to Prof. Albert Haertlein of the Harvard Graduate School of Engineering, and Prof. John B. Babcock, 3rd, of M. I. T. received a special prize for his paper on the Boston Society of Civil Engineers; the sanitary section prize for papers was presented to Almon L. Fales, and the designers section prize was awarded to Herman G. Dresser.



NEW engineering building and power plant for New York University.

New York University Dedicates New Engineering Laboratory

A new engineering laboratory and power plant for New York University was dedicated on April 3, the exercises being made the occasion for public recognition of the long service to the University of Dean emeritus Collins P. Bliss, for whom the new building is named.

The new building stands at the south side of the University Heights campus and because of the slope of the land is three stories high on the campus side and five stories high on the 180th St. side. It contains classrooms, laboratories for the civil engineering and meteorology department, a large engineering library and, in the lower floors a power plant designed to supply both heat and light to all buildings on the campus. The capacity of the power plant is such that it can supply the power necessary to produce air speeds up to 100 m.p.h. in the wind tunnel of the nearby Guggenheim Aeronautics Laboratory.

Civil engineering facilities include materials testing and hydraulic laboratories, a hydraulic demonstration classroom, and laboratories for cement and bituminous materials. The meteorological laboratory occupies part of the upper floor and the roof.

Dean Bliss retired as head of the engineering department last September. At the dedication exercises he was presented with an engrossed scroll by Arthur S. Tuttle, chairman of the council committee on engineering, New York University. Other speakers at the dedication exercises and at the luncheon that followed included Chancellor Chase of the university, Harvey N. Davis, president Stevens Institute of Technology, W. R. Gregg, chief of the U. S. Weather Bureau, Prof. D. B. Trowbridge of the university staff, Dean Bliss and Dean Thorndike Saville who succeeded Dean Bliss as head of the engineering school.

Personals

WILLIAM GEBHART has been appointed assistant engineer in charge of bridges for Stark County, Ohio.

RICHARD WILLIAMS has been appointed topographical engineer of Nassau County, New York.

FELIX J. KEAVENY has joined Max B. Miller & Co., New York City, as structural designer.

F. W. PANHORST, acting bridge engineer, has been appointed bridge engineer of the California division of highways.

ARTHUR H. PEAKE, formerly county engineer of Scioto County, Ohio, has been appointed WPA assistant field engineer in charge of projects in Ross County.

BRIGGS SMITH, formerly commissioner of highways in Tennessee, has been appointed maintenance engineer for the Tennessee state highway department.

ARTHUR B. HALE, a civil engineer of Tampa, Fla., has been appointed chairman of the Florida state highway commission, succeeding Chester B. Treadway.

GEORGE L. FREEMAN and WILLIAM H. MUESER have been admitted to partnership in the consulting engineering firm of Moran & Proctor. The firm name will be changed to Moran, Proctor & Freeman.

WILLIAM GARVIN, JR., has been employed as civil engineer for the Kentucky Rock Asphalt Company. Mr. Garvin was formerly connected with the Kentucky state highway department.

STUART M. WEAVER, eastern field consultant for the American Municipal Association and formerly city director and before that city engineer of Monroe, Mich., has been appointed superintendent of the water bureau and executive assistant to the director of the department of public works of Montclair, N. J.

JACKSON B. HAYDEN, assistant town engineer of Montclair, N. J., has been appointed town engineer. Mr. Hayden, who had been connected with the engineering department of the town for ten years, has been serving as acting town engineer since Jan. 14, when Edgar F. Martin, the former engineer, was shifted to the position of superintendent of the bureau of water supply.

Steel Congress Cancelled

Owing to the extreme pressure of steel business in Europe the Sixth International Congress for Steel Development, which had been scheduled to meet in New York under the sponsorship of the American Institute of Steel Construction the last week of June, 1937, has been cancelled. This step was taken at the request of the steel industries abroad. No date or place for this postponed meeting has as yet been set, this depending very largely upon the development of events in Europe.

The Fifth International Congress met in Berlin in October, 1936. The Institute was to have been host to the Sixth Congress.

Obituary

JESSE A. RUFFNER, retired construction contractor active in highway construction in and around Cincinnati, Ohio, died there, March 30, at the age of 83.

JAMES COOPER, 51, city engineer of Reading, Ohio, died near there, March 26. Mr. Cooper had in the past been city engineer of Lockland, Ohio, and had done work for the Southern Railroad in Cincinnati.

LAURENCE W. PIERCE, a civil engineer living at South Orleans, Mass., died there March 31, at the age of 59. A graduate of Williams College, Mr. Pierce practiced his profession in many foreign countries.

OSCAR M. GWIN, 59, New Orleans general contractor, died there recently. Mr. Gwin formed the O. M. Gwin Construction Co., 20 years ago and has erected many large buildings in New Orleans and Mobile.

HOWARD N. HOOD, engineer for the U. S. government, was drowned during the recent Mississippi flood when he fell from a patrol boat in which he was riding. His body was found on an island in the Mississippi River near Eudora, Ark., on March 24.

ADOLPH LEVY, 69, sanitary and construction engineer, of Cincinnati, died there March 30. Until his retirement four years ago, Mr. Levy was active in the sanitary field and was responsible for sewer installations in many cities throughout the country.

GEORGE ALEXANDER, former commissioner of public works at Quincy, Mass., and for many years a consultant in water works engineering, died in Belmont, Mass., March 30, at the age of 81. He had practiced in Boston for 20 years at the time of his retirement in 1930.

FRED W. LUMIS, building commissioner of Springfield, Mass., for the last 26 years, died there March 29 at the age of 76. Mr. Lumis, appointed building commissioner in 1910, wrote the first building code for the city. He was for five years president of the Association of Massachusetts Building Inspectors.

JOSEPH M. HOWE, 63, consulting civil engineer of Houston, Texas, died there March 22. A graduate of Massachusetts Institute of Technology in 1896, Mr. Howe was engaged on much of the pioneer railroad construction in New Mexico, working from 1897 until 1904 with the Santa Fe, the Houston and Texas Central, and the Southern Pacific Railroads. In 1904 he began private practice in civil engineering and in 1909 became associate with A. J. Wise in the construction of sewers, water works and pavements for Texas municipalities. Mr. Howe was a past president of the Texas Section of the American Society of Civil Engineers.

LARGER AWARDS FOR THE WEEK

Light plant, Pennsylvania Electric Company, Seward, Pa.	$2,500,000
Truck depot, Truck Depot, Incorporated, Chicago, Ill.	500,000
Tire plant and equipment, Ford Motor Company, River Rouge, Mich.	2,200,000
Residential development, Huntleigh Village, Mo.	1,000,000
Apartment, Cornell Apartment Corporation, New York, N. Y.	500,000
Three laboratory buildings, California Institute of Technology, Pasadena, Calif.	1,300,000
School, Public School No. 253, Brooklyn, N. Y.	633,000
School, Public School, No. 117, New York, N. Y.	990,000
Superstructure, Andrew Jackson Courts Housing Project, Nashville, Tenn.	1,278,000
Construction, Laurel Homes Project, Cincinnati, O.	608,000
Equipment for power plant, Board of Water and Electric Light Commissioners, Lansing, Mich.	1,500,000
Highways, Oregon	598,000
Highways, South Dakota	726,000
Constructing two concrette arch dams, Schedule No. 1 and No. 2, Colorado River Aqueduct, Los Angeles, Calif.	594,000
Outlet conduit and junction chamber, sewage disposal plant, Detroit, Mich.	1,610,000
Repairing and rebuilding telephone lines between Hannibal, Mo., and Midland, Tex., Southwestern Bell Telephone Company, St. Louis; in Ark., Kan., Mo., Okla., and Tex. Estimate	1,500,000
Hockey arena, Cleveland Hockey, Incorporated, Cleveland, O.	750,000

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Apr., 1937	230.25	110.64	Mar., 1937	147	64
Mar., 1937	225.25	108.18	Feb., 1937	181	79
Apr., 1936	202.20	97.20	Mar., 1936	160	70
1936 (Av.)	206.46	99.24	1936 (Av.)	185	81
1935 (Av.)	195.22	93.84	1935 (Av.)	135	58
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50

CONTRACTS
(Thousands of Dollars)

	Weekly Average Apr. 1936	Prev. 4 Weeks	Week Apr. 8 1937
Fed. Government	$1,386	$3,798	$3,247
State and Municipal	24,965	15,391	19,718
Total public	$26,351	$19,189	$22,965
Total private	12,741	20,646	27,813
Week's total	**$39,092**	**$39,835**	**$50,778**

Cumulative to date:
1936 (15 weeks) $674,540,000
1937 (14 weeks) $604,518,000

Note: ***Engineering News-Record*** **reports waterworks and earthwork, reclamation or** waterways projects of $15,000 and over in size; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000 and over. The figures above represent the **volume of contracts and large force account** projects throughout the U. S. that are of **these minimum sizes or over.**

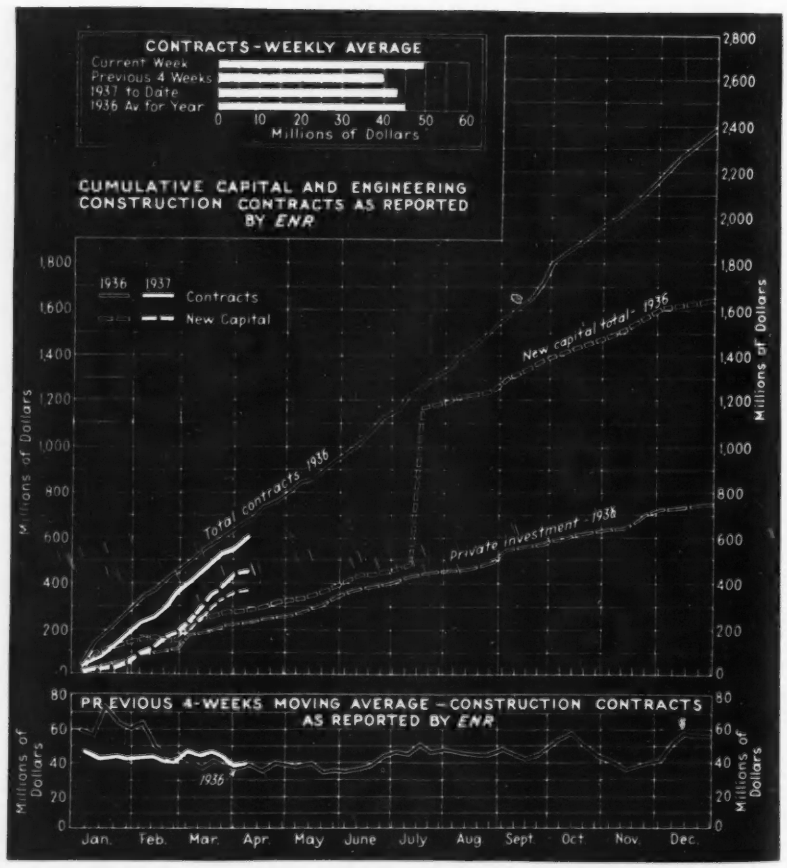
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1937	Week Apr. 8	Cumulative
Private investment	**$13,888**	**$378,902**
State and municipal bonds	4,025	165,497
Corporate securities	9,863	213,405
Federal financing	.....	**$75,701**
PWA non-federal		
Projects	.....	46,569
R.F.C. Loan	.....	29,132
Total non-federal	**$13,888**	**$454,603**
Federal projects	.....	.....
Total	**$13,888**	**$454,603**

Cumulative to date:
1936 (15 weeks) $311,417,000
1937 (14 weeks) $454,603,000

Note: These figures include private bonds and stocks sold for new construction purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities. RFC direct purchase of bonds for "self liquidating" projects, and 25 per cent of WPA construction appropriations.

* Includes transfer from federal to private investment financing through sale by RFC of PWA bonds.



Current Construction Unit Prices

Railroad Facilities, San Francisco Bridge

CONTRACT was awarded in February, 1937, for the construction of the substructure of the railway facilities of the San Francisco-Oakland Bay Bridge, with the right reserved by the bridge authorities to later reduce the amount of the contract by the cost of the work involved in the substructure of the Port of Oakland overhead.

The following tabulation lists the quantities, unit prices and totals of the three low bidders for the work which is to be under the jurisdiction of C. H. Purcell, chief engineer of the Bridge Authority: (A) Bates & Rogers Const. Co. (contract) Chicago, Ill., $684,802; (B) J. F. Knapp, Oakland, Cal., $696,050, (C) Basich Bros., Torrance, Cal., $774,159.

RAILROAD FACILITIES, SAN FRANCISCO BAY BRIDGE

Item	A	B	C
East Bay Yard Substructure:			
1. Excavation—16,000 cu.yd.	$2.30	$0.75	$2.00
2. Creosoted piles, 40-59 ft.—20,000 lin.ft.	1.09	1.25	1.07
3. Creosoted piles, 60-79 ft.—25,000 lin.ft.	1.19	1.15	1.16
4. Creosoted piles, 80 ft., plus—35,000 lin.ft.	1.37	1.10	1.33
5. Untreated piles, 40-54 ft.—20,000 lin.ft.	.53	.60	.58
6. Untreated piles, 55-69 ft.—30,000 lin.ft.	.54	.80	.58
7. Untreated piles, 70-84 ft.—40,000 lin.ft.	.57	.75	.64
8. Untreated piles, 85 ft., plus—87,000 lin.ft.	.62	.70	.71
9. Footing concrete—6,450 cu.yd.	8.25	12.00	14.00
10. Concrete, above ftgs.—1,700 cu.yd.	18.15	18.00	27.18
11. Reinforcing steel—1,400,000 lb.	.046	.0475	.05
12. Anchor bolt material—80,700 lb.	.155	.10	.10
13. Untreated timber—80 M.B.M.	67.00	55.00	88.03
14. Creosoted timber—880 M.B.M.	122.00	110.00	120.00
15. Timber hardware—62,000 lb.	.09	.10	.10
16. Extra portland cement—2,600 bbl.	2.37	2.25	2.75
Substructure—Port of Oakland Overhead			
17. Excavation—2,800 cu.yd.	4.55	5.00	2.00
18. Untreated piles, 55-69 ft.—8,000 lin.ft.	.54	.80	.58
19. Untreated piles, 70-84 ft.—9,000 lin.ft.	.57	.75	.64
20. Untreated piles, 85 ft., plus—70,000 lin.ft.	.62	.70	.71
21. Footing concrete—1,750 cu.yd.	9.05	12.00	12.75
22. Concrete above ftgs.—1,600 cu.yd.	18.90	18.00	28.83
23. Reinforcing steel—600,000 lb.	.043	.045	.049
24. Anchor bolt material—20,000 lb.	.155	.10	.10
25. Rock, wall—1,000 cu.yd.	9.10	5.00	3.50
26. Sand, fill—5,000 cu.yd.	.85	.50	2.50
27. Imported base material—1,600 ton	1.00	1.25	1.75
28. Crusher run base—800 ton	2.00	2.50	2.25
29. Asphalt concrete—400 ton	4.95	6.00	4.50
30. Extra portland cement—400 bbl.	2.37	2.25	2.75

Kentucky River Bridge, Frankfort, Ky.

PROPOSALS for the construction of a state highway bridge 1,652 ft. long over the Kentucky River at Frankfort, Ky., indicate cement concrete type pavement as 9 to 10 per cent lower in price than alternative types of rock-asphalt and bituminous surfacing. Five bids were submitted for the former ranging from the contract low of $173,696 to a high of $222,539, with one bid only for the rock asphalt surfacing at $191,406, and another only for the bituminous paving at $192,433. On the 1,000-ton structural steel and concrete superstructure, five bids submitted ranged from the contract low of $157,607 to a high of $227,956.

The following tabulations list the quantities, unit prices and totals of the three low bidders on the two divisions of the work: Substructure—(A) Sandy Hites Co. (contract) Kansas City, Mo., $173,696; (B) Robt. H. King, Danville, Ill., $188,594; (C) C. H. Atkinson Paving Co., Chillicothe, Mo., $192,676. Superstructure—(D) Bethlehem Steel Co., Bethlehem, Pa. (contract) $157,607; (E) Nashville Bridge Co., Nashville, Tenn., $162,786; (F) Wisconsin Bridge & Iron Co., $167,576.

KENTUCKY RIVER BRIDGE, FRANKFORT, KY.

Item	A	B	C
Substructure			
1. Concrete, cl. A—4,313.3 cu.yd.	$18.00	$21.25	$18.00
2. Concrete, cl. D—5.7 cu.yd.	50.00	35.00	50.00
3. Steel reinforcing—181,540 lb.	.04	.045	.0425
4. Remove stone masonry—4,600 cu.yd.	3.00	2.00	2.00
5. Bronze expansion plates—460 lb.	.50	.75	.50
6. Dry rock rip rap—690 sq.yd.	4.00	3.00	2.50
7. Memorial tablets—2 each	200.00	200.00	150.00
8. Concrete piles, 14 in.—4,500 lin.ft.	2.25	3.00	2.50
9. Struct. excav. No. 1—2,330 cu.yd.	1.80	2.00	3.00
10. Struct. excav. No. 2,—210 cu.yd.	15.00	10.00	20.00
11. Struct. excav. No. 3—620 cu.yd.	13.00	15.00	20.00
12. Struct. excav. No. 4—1,830 cu.yd.	8.50	8.00	15.00
Approaches and Lighting System			
13. Roadway, drainage excav.—800 cu.yd.	.75	1.00	.75
14. Structure excav.—2,700 cu.yd.	1.25	1.00	2.00
15. Sand, gravel backfill—2,400 ton	2.00	1.90	1.80
16. Scarify, reshape—1,500 sq.yd.	.15	.20	.15
17. Remove stone wall—65 lin.ft.	3.00	1.50	1.60
18. Remove sidewalk—415 sq.yd.	.40	.35	.20
19. Remove pipe—200 lin.ft.	2.00	1.00	.80
20. Relay pipe—50 lin.ft.	1.50	1.00	.50
21. Remove concrete masonry—20 cu.yd.	3.00	3.00	5.00
22. Remove car tracks, conc.base—640 lin.ft.	1.50	2.00	2.00
23. Remove inlets—6 each	20.00	25.00	6.00
24. Remove, rebuild inlets—2 each	120.00	75.00	60.00
25. Remove, replace wire fence—40 lin.ft.	.10	.20	.40
26. Adjust coal chutes—2 each	25.00	10.00	10.00
27. Remove valley gutter—200 lin.ft.	.50	.35	.25
28. Remove curb, gutter—460 lin.ft.	.30	.35	.35
29. Concrete junction box—1 each	75.00	75.00	85.00
30. C. I. pipe, 12 in., lock joint—20 lin.ft.	3.50	3.00	2.50
31. Concrete, cl. A, walls, steps—35 cu.yd.	30.00	22.00	25.00
32. Manholes—48 vert.ft.	10.00	15.00	8.50
33. Curb, gutter basin, " Y " trap—2 each	100.00	125.00	50.00
34. Special inlets—5 each	85.00	100.00	80.00
35. Special inlets, " Y " traps—2 each	100.00	150.00	85.00
36. Concrete sidewalk, 4 in.—605 sq.yd.	1.80	1.75	2.00
37. Concrete sidewalk, 5 in.—335 sq.yd.	2.00	1.90	2.25
38. Concrete base—142 sq.yd.	2.40	3.00	1.50
39. Asphalt cutback paint—142 sq.yd.	.15	.10	.50
40. Rock asphalt—7 ton	20.00	20.00	16.00
41. Curb, gutter, 6 in.—170 lin.ft.	1.00	1.00	1.30
42. Rural catchbasin, traps—3 each	70.00	100.00	45.00
43. Borrow—3,000 cu.yd.	.60	.80	.50
44. Reconstruct driveways—total	100.00	25.00	150.00
45. Lighting system—total	54.00	5,000	5,500
46. Crushed limestone entrance—10 ton	3.00	2.50	2.00
47. Drainage pipe, 4 in.—100 lin.ft.	1.00	.40	.50
48. Drainage pipe, 6 in.—100 lin.ft.	1.00	.45	.75
49. Drainage pipe, 10 in.—24 lin.ft.	1.25	.75	1.00
50. Drainage pipe, 15 in.—717 lin.ft.	2.00	1.25	1.50
51. Drainage pipe, 18 in.—126 lin.ft.	2.50	1.50	2.00
52. Drainage pipe, 30 in.—585 lin.ft.	4.00	6.00	3.00
Alternative Surfacing			
53. Concrete paving—5,083 sq.yd.	2.70	2.25	2.60
54. Integral curb, 10 in.—507 lin.ft.	.60	.75	.40
55. Integral curb, 6 in.—825 lin.ft.	.40	.60	.30
56. Concrete base—4,637 sq.yd.	.....	2.15	.....
57. Asphalt cutback paint—4,637 sq.yd.	.....	.10	.....
58. Rock asphalt—210 ton	.....	15.00	.....
59. Curb, gutter, 10 in.—507 lin.ft.	.....	1.25	.....
60. Curb, gutter, 6 in.—825 lin.ft.	.....	1.10	.....
61. Concrete base—4,637 sq.yd.	.....	2.15	.....
62. Bitum. surf. type A—464 tons.	.....	10.00	.....
63. Curb and gutter, 10 in.—507 lin.ft.	.....	1.25	.....
64. Curb and gutter, 6 in.—825 lin.ft.	.....	1.10	.....
Bridge Superstructure	D	E	F
1. Concrete, cl. A—782.2 cu.yd.	$22.00	$20.00	$25.00
2. Concrete, cl. D—97.7 cu.yd.	67.50	35.00	50.00
3. Steel reinforcing—166,860 lb.	.0467	.049	.0422
4. Trap doors, sidewalk—6 each	23.23	25.00	20.00
5. Struct. steel—2,094,230 lb.	.0597	.0642	.0645
6. Creosoted Y. P. timber, select—6.314 M.B.M.	134.00	150.00	142.00

Sardis Dam, Mississippi

BIDS were opened March 9, 1937, by the U. S. District Engineer at Vicksburg, Miss., for the construction of the Sardis hydraulic-fill dam on the Little Tallahatchie River in northern Mississippi. The main embankment, of which the top 10 ft. is rolled fill, will be 96 ft. high and

8,700 ft. long. Earth dikes extend from each abutment for a total of 4,300 ft. more. Principal quantities include 14,000,000 cu.yd. of fill and 2,364,000 cu.yd. of excavation. Some 12½ million yd. will be placed hydraulically by floating dredges. Minimum wage rates specified vary from 50c. for common labor to $1 for equipment operators. The work must be completed within 1,200 calendar days; penalty for delay is $300 daily.

Six bids were submitted, ranging from $3,976,927 to $5,915,020, all way above the engineer's estimate of $2,879,857. Following are unit prices of the three low bidders. (A) General Const. Co., Seattle, Wash., $3,976,927; (B) Atlas Const. Co., Dallas, Tex., and Boyce & Igo, Baton Rouge, La., $3,985,477; (C) Minneapolis Dredging Co., Minneapolis, Minn., $4,796,740. Lt.-Col. L. E. Oliver is district engineer.

SARDIS DAM, LITTLE TALLAHATCHIE RIVER, MISSISSIPPI

Item	A	B	C
1. River diversion—job	$145,000	$20,000	$150,000
2. Excavation—2,364,000 cu.yd.	0.25	0.38	0.42
3. Rolled fill—1,678,000 cu.yd.	.11	.08	.08
4. Hydraulic fill—12,545,000 cu.yd.	.2375	.2266	.274
5. Gravel filter—9,200 lin. ft.	2.40	4.00	4.00
6. Pipe, 12-in. corr. metal—700 lin. ft.	1.80	3.00	4.00
7. Pipe, 18-in. corr. metal—8,630 lin. ft.	2.30	4.00	3.00
8. Pipe, 24-in. corr. metal—3,360 lin. ft.	3.00	5.00	5.00

Dam and Reservoir, Mass.

CONTRACT was awarded in December, 1936, by the Southbridge Water Supply Co., Southbridge, Mass., for the construction of its No. 5 dam and reservoir as designed by Fay, Spofford and Thorndike, engineers, Boston. Alternative bids were taken on cast iron and transite line with the contract being awarded on the former basis. Twelve bids were received ranging from the contract low of $144,987 to a high of $225,936. The following tabulation lists the unit prices and totals of the three low bidders. (A) J. F. Fitzgerald Construction Co., (contract) Boston, Mass., $144,987 (transite pipe $145,677); (B) C.&R. Const. Co., Roslindale, Mass., $149,531 (transite pipe $148,631); (C) Tuller Const. Co., Red Bank, N. J., $155,060 (transite pipe $153,060).

DAM AND RESERVOIR, SOUTHBRIDGE, MASS.

Item Description	A	B	C
1. Clear dam, reservoir site — total	$1,200	$3,600	$2,000
2. Grub — 50,000 sq. yd.	.07	.05	.06
3. Cast over cut — 1,800 lin. ft.	.30	.25	.65
4. Strip in reservoir site — 50,000 sq. yd.	.15	.15	.12
5. Blanketing in reservoir site — 34,000 sq. yd.	.12	.15	.16
6. Earth, gravel embankment — 52,000 cu. yd.	.30	.40	.38
7. Stone embankment — 7,000 cu. yd.	2.00	.50	.80
8. Hand placed paving — 1,400 sq. yd.	2.50	.70	.70
9. Loam surfacing, seeding — 9,600 sq. yd.	.06	.25	.40
10. Outlet conduit, stream control — total	5,722	7,300	7,500
11. Trench excav., core walls, spillways — 600 cu. yd.	3.00	2.00	1.50
12. Corewall, spillway concrete — 1,400 cu. yd.	19.25	23.00	19.00
13. Blind drains — 670 lin. ft.	.50	.30	1.00
14. Paved gutters — 1,000 lin. ft.	2.50	1.00	.60
15. Gate house — total	10,198	15,300	15,000
16. Cast iron pipe, fittings — total	29,768	27,900	38,000
17. Lay cast iron pipe — total	17,218	17,600	18,000
18. Transite pipe, etc.— Alternative — total	30,458	28,970	37,500
19. Lay transite pipe, etc.— alternative — total	17,218	15,630	16,500

Shafts for Delaware River Aqueduct

CONSTRUCTION of the Delaware River aqueduct to furnish New York City with additional water supply started with the recent award of contracts for four groups of deep shafts scattered from Rondout Creek in the Catskills to Hill View Reservoir in Yonkers. The contracts include 23 shafts at 18 sites. There are seven more shafts required, which will probably be included with tunnel contracts to be awarded at a later date. The shafts vary in size from 14 ft. to 26 ft. finished diameter and in depth from 310 ft. to 1,550 ft. All work is being done by the New York Board of Water Supply under the direction of Walter E. Spear, chief engineer.

Following are unit prices and total bids of the three low bidders on three of the four contracts.

Contract 332—Shafts 2, 2A and 3:

(A) Dravo Contr. Corp., Pittsburgh (contract)	$1,738,250
(B) Geo. H. Flinn Corp., New York	1,812,424
(C) W. E. Callahan Const. Co. & J. P. Shirley, Dallas Tex.	2,038,900

Contract 331—Shafts 7, 8, 9 and 10:

(D) W. E. Callahan Const. Co. & J. P. Shirley, Dallas, Tex. (contract)	1,926,150
(E) Cogan Bros., Inc., New York	1,980,070
(F) Walsh Const. Co., Davenport, Ia.	2,041,938

Contract 333—Shafts 4, 5, 5A and 6:

(G) Frazier-Davis Const. Co., St. Louis (contract)	2,294,415
(H) Geo. H. Flinn Corp., New York	2,296,840
(J) Walsh Const. Co., Davenport, Ia.	2,314,055

SHAFTS FOR DELAWARE RIVER AQUEDUCT, NEW YORK

		Shafts 2-2A-3				Shafts 7-8-9-10				Shafts 4-5-5A-6			
Item	Description and Bidders	Quant.	A	B	C	Quant.	D	E	F	Quant.	G	H	J
1.	Test borings — lin.ft.	1,000	$7.50	$4.50	$6.00	1,000	$6.00	$7.50	$10.00	1,000	$6.00	$5.00	$10.00
2.	Earth excav., refilling—cu.yd.	12,000	1.25	16.76	6.00	13,000	13.00	2.00	9.54	26,000	1.70	8.11	9.35
3.	Rock excav.— cu.yd.	55,000	20.50	16.76	22.70	51,000	17.00	24.00	21.00	72,000	20.00	16.18	15.50
4.	Enlarge shafts, tunnels — cu.yd.	750	20.00	9.81	24.00	1,000	30.00	24.00	21.00	1,000	20.00	10.00	15.50
5.	Struct. steel, shafts, tunnels — lb.	250,000	.10	.06	.10	350,000	.10	.08	.085	350,000	.10	.0625	.085
6.	Timber and lumber — M.B.M.	550	110.00	107.89	100.00	500	110.00	100.00	100.00	850	110.00	100.00	100.00
7.	Dry packing — cu.yd.	200	3.50	5.79	20.00	300	25.00	5.00	3.50	300	6.50	4.80	3.50
8.	Pumping — mil. gal. ft.	10,000	.50	1.50	2.50	7,500	2.50	1.00	.30	15,000	.80	.50	.30
9.	Drainage channels — lin.ft.	4,600	1.50	4.00	4.00	5,000	30.00	5.00	13.74	5,300	6.00	7.00	10.40
10.	Masonry lining forms — lin.ft.	3,200	10.00	9.00	25.00	3,200	20.00	15.00	27.54	3,450	10.00	25.00	24.30
11.	Concrete masonry — cu.yd.	15,000	15.00	15.00	10.00	13,000	15.00	15.00	18.84	17,500	15.00	14.50	15.50
12.	Excess concrete masonry — cu.yd.	500	5.00	5.00	5.00	600	5.00	5.00	5.00	800	5.00	5.00	5.00
13.	Bitum. curing, conc. masonry—sq.yd.	8,000	.03	.09	.40	10,000	.15	.15	.15	8,000	.08	.10	.15
14.	Drill up to 1½ in. holes — lin.ft.	200	.80	1.16	2.50	300	1.00	1.50	.75	300	.50	1.20	.75
15.	Drill from 1¾ to 2½ in. holes — lin.ft.	3,000	1.00	1.45	2.50	3,000	1.25	2.00	.75	4,000	.80	1.50	.75
16.	Steel grout pipes — lin.ft.	3,000	1.00	.31	1.00	3,600	1.25	1.00	.60	4,000	.80	.50	.60
17.	Make grout connections — connection	750	2.50	3.69	10.00	800	6.00	3.50	5.00	1,000	2.50	3.22	5.00
18.	Sand, filters and grout — cu.yd.	2,500	2.50	2.58	2.50	2,500	5.00	5.00	3.75	1,700	4.00	2.60	3.75
19.	Mix, place grout — cu.yd.	1,000	15.00	18.20	35.00	1,200	25.00	15.00	15.10	1,600	12.00	16.00	15.00
20.	Steel sheet piling lb.	75,000	.045	.05	.08	.....	.....	.....	.....	.....	.....	.....	.....
21.	Structural steel — lb.	20,000	.08	.07	.10	30,000	.15	.08	.06	165,000	.10	.07	.06
22.	Portland cement — bbl.	35,000	2.80	2.60	3.00	32,000	3.00	3.00	2.65	43,000	2.60	2.70	2.75
23.	Reinforcing steel — lb.	15,000	.05	.06	.07	30,000	.07	.06	.055	45,000	.06	.07	.055
24.	Misc. cast iron, w. i. steel — lb.	30,000	.12	.12	.20	18,000	.20	.14	.20	27,500	.16	.12	.20
25.	Steel pipes, fittings — lb.	400,000	.08	.12	.15	350,000	.15	.14	.08	420,000	.10	.09	.08
26.	Vitrified pipes — lin.ft.	6,000	1.00	.73	2.00	5,000	2.50	2.50	1.45	8,000	2.50	1.19	1.70
27.	Dry rubble masonry, paving — cu.yd.	200	6.00	7.44	15.00	300	8.00	7.00	9.00	200	5.00	7.70	9.00
28.	Rubble masonry, mortar — cu.yd.	200	9.00	9.76	18.00	200	12.00	9.00	11.00	200	8.00	10.10	11.00
29.	Crushed stone, gravel — cu.yd.	1,800	1.50	3.00	3.00	1,100	3.00	5.00	4.50	250	3.50	3.10	4.50
30.	Engineer's offices — sq.ft.	4,000	2.50	5.77	5.50	5,000	5.00	6.50	8.00	4,600	5.00	7.50	8.00
31.	Chlorinators — each	7	1,800	2,250	3,000	8	2,500	2,500	3,000	6	4,000	3,000	3,000
32.	Liquid chlorine — lb.	15,000	.10	.09	.10	50,000	.10	.12	.10	5,000	.12	.10	.10
33.	Sanitary services — total	.....	10,000	50,000	15,000	.....	25,000	40,500	30,000	.....	10,000	50,000	30,000
34.	Clean up — total	.....	1,000	26,750	8,000	.....	3,000	8,000	45,000	.....	5,000	25,000	45,000
35.	Refill, embank.— cu.yd.	.....	.....	.....	.....	6,000	.75	1.50	.80	.....	.....	.....	.....
36.	Cast iron pipe, fittings — lb.	.....	.....	.....	.....	30,000	.20	.14	.12	.....	.....	.....	.....
37.	Misc. non-ferrous metals — lb.	.....	.....	.....	.....	2,500	.60	1.00	.60	.....	.....	.....	.....